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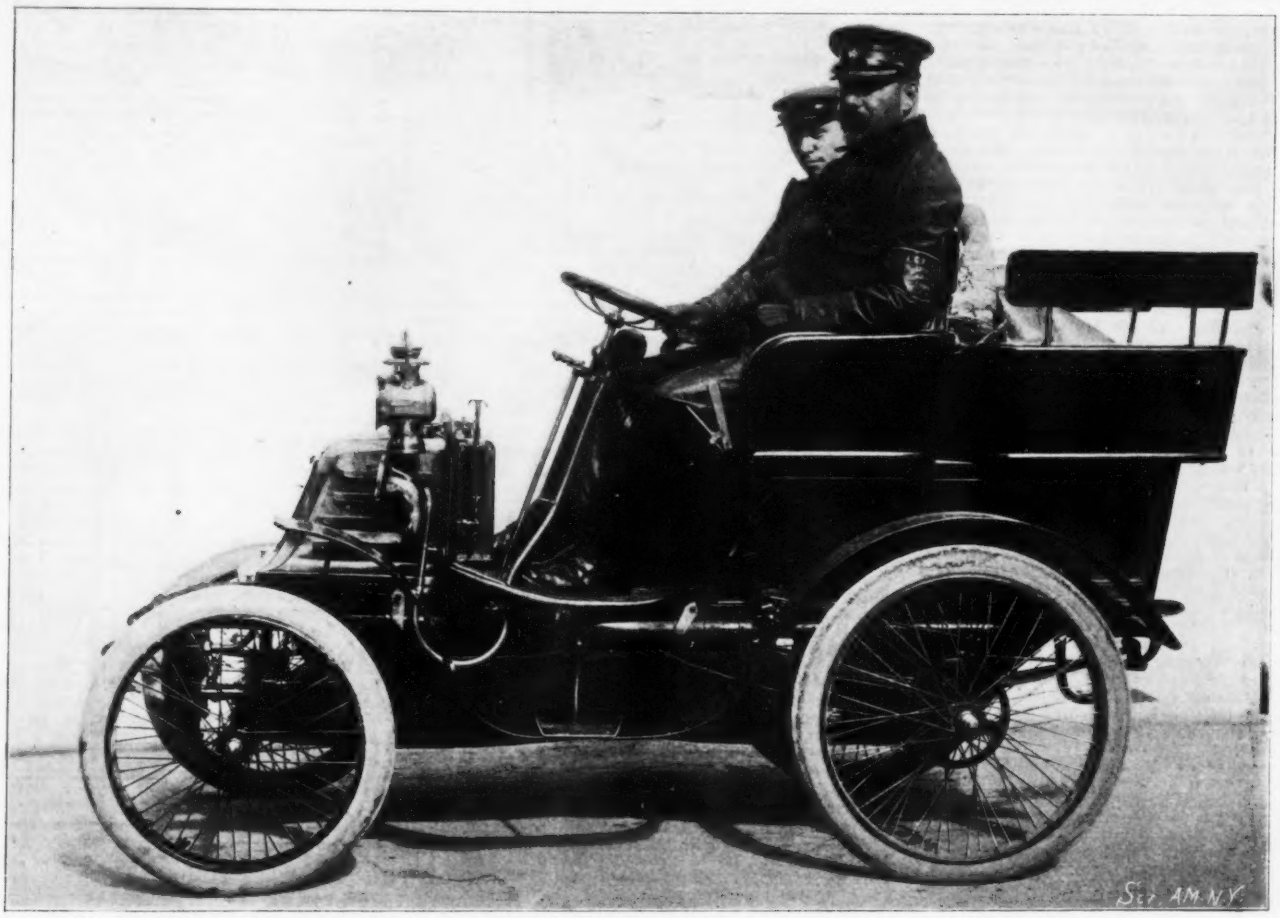


ONE OF THE CONTESTANTS IN THE PARIS-BERLIN RACE.—4 HORSE POWER "PONY" CARRIAGE.

THE GEORGES RICHARD 5½ HORSE POWER "PONY" AUTOMOBILE.

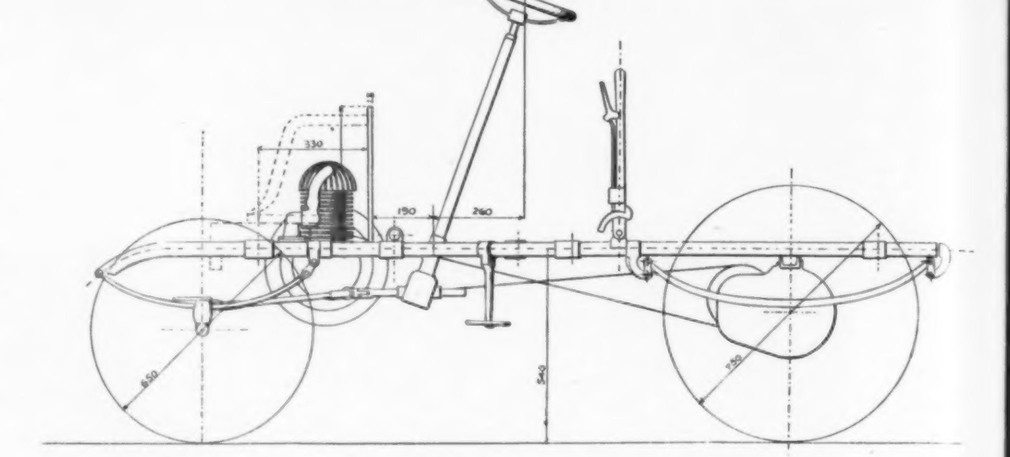
THE GEORGES RICHARD AUTOMOBILE.

By PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

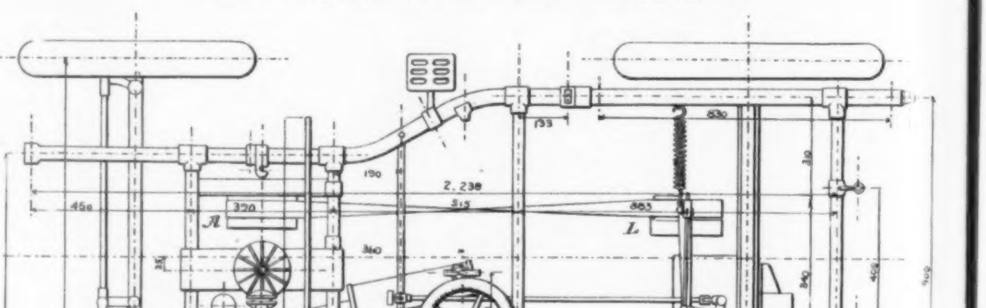
THE new type of light automobile of the voiturette class which has been lately brought out by the Georges Richard firm, of Paris, has already met with considerable success, and showed a good performance in the Paris-Berlin race, where several of these light machines, known as "Pony" automobiles, were entered together with the heavier machines built by the same company. The photographs show two of these light machines taken at the time of the Paris-Berlin race with their chauffeurs mounted for the start. Two of our figures show the plan and elevation of the truck, and the remaining figures some of the details of the mechanism. The motor drives the rear wheels, the front pair being used for steering; the latter run upon ball bearings, while the rear wheels have smooth bearings, with oil rings. The frame of the truck is constructed of steel tubes, with welded joints. The motor and its accessories are placed toward the front in a box whose form is varied to suit the carriage-body. Three types of this machine are built, carrying motors of 4, 5½, or 9 horse power. The first type, of 4 horse power, which is seen in one of the engravings, has a vertical, single cylinder motor (cylinder 3.8 inches diameter and 4-inch stroke) with electric ignition by accumulators and a spark igniter of improved form. A special arrangement for cooling the motor by means of a mechanical ventilator has been adopted, and is one of the most successful features of this machine. Motors with the ordinary type of cooling wings, of which the De Dion is a good example, offer great advantages of simplicity which make them preferred for the smaller powers, but unfortunately they do not always give entire satisfaction on account of the insufficient cooling when the vehicle moves slowly and the current of air is small; this is especially noticed in hill-climbing. To remedy this the Richard machine uses a small fan which is mounted on ball-bearings and consequently takes but little power. It is set in motion by a friction-roller in contact with the flywheel of the motor. This ventilator blows a current of air against the motor cylinder, and thus the cooling is independent of the speed of the vehicle.

Transmission is made from the motor to the rear wheels by a belt which passes over a set of loose and fixed pulleys (*A* and *L* in the diagram), one set being mounted on the motor shaft and the second on a shaft in front of the rear axle. To throw the motor in and out of gear this belt is shifted by a fork connected to a foot-lever in front of the conductor. The rear pulley, *L*, drives the differential of the rear axle by means of a set of intermediate gears which may be shifted to give three different speeds and reversal to the rear wheels. This arrangement is shown in the diagram, where *L* is the main pulley driven by the belt from the motor, mounted on the main shaft, *S*. This shaft carries a pair of gears, *AB*, which are keyed to it and may be shifted to the left by the speed-changing lever. To the left is a similar pair of gears, which turn loose upon the shaft in ball-bearings. Above is an auxiliary shaft, *H*, upon which turn a set of loose pulleys, *EFG*, geared to the lower set as shown. In the first position (that of the diagram) the gear, *B*, drives *G* and this motion is transmitted by *E* to *D* and *C*, the latter driving the differential of the rear axle. By shifting *AB* to the left, *A* engages with the middle gear, *F*, and this gives the second speed. When *A* is shifted so as to touch *D*, it engages with it by a clutch and drives it directly, the upper shaft being out of action; this gives the third speed. To give the reversal, the set, *AB*, is shifted so as to be out of contact with the upper set, and is then connected with it by an auxiliary gear which may be thrown in from the side by a lever; this drives the upper set in the reverse direction, and in consequence, the differential.

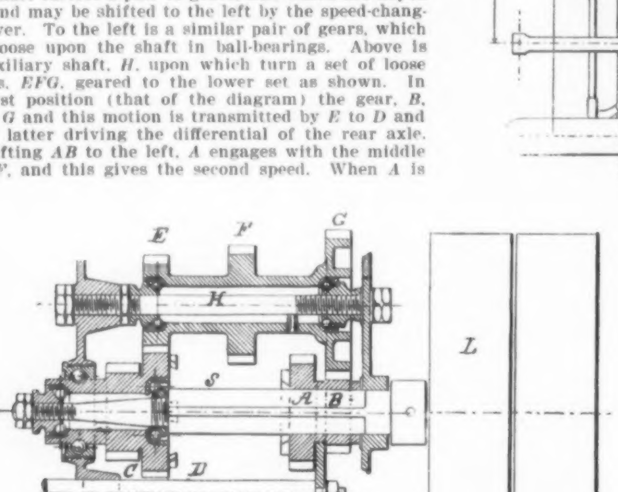
One feature of this machine is the extensive use of ball bearings, also of protecting cases containing oil. A hand brake is provided, which acts upon the motor wheels, and by a pedal a band brake is thrown on the differential. The type Pony No. 1 weighs 650 pounds and occupies a space 90 by 60 inches; it has three speeds of 6, 12 and 18 miles an hour. The type No. 2 has a 5½ horse power motor, single cylinder, with water cooling by pump and radiators. No. 3 is a larger type of 9 horse power, with a two-cylinder motor, water cooled. The form of carriage body is varied; the photographs show two of the most current types.



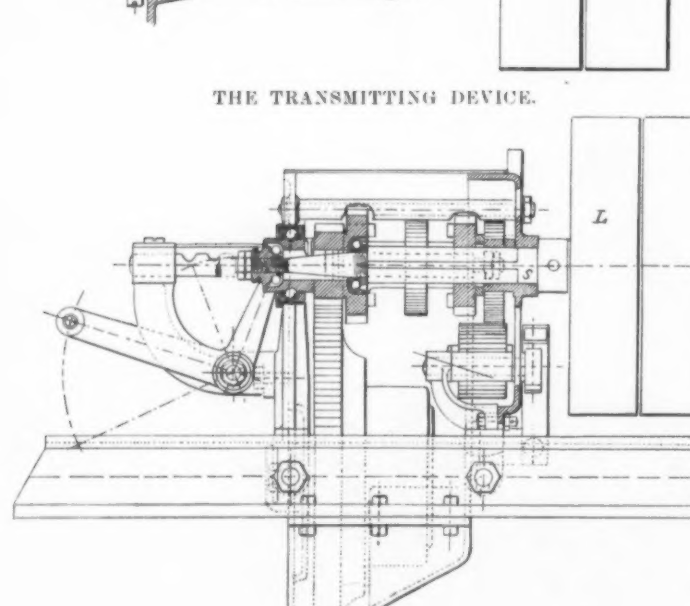
SIDE ELEVATION OF THE "PONY" AUTOMOBILE.



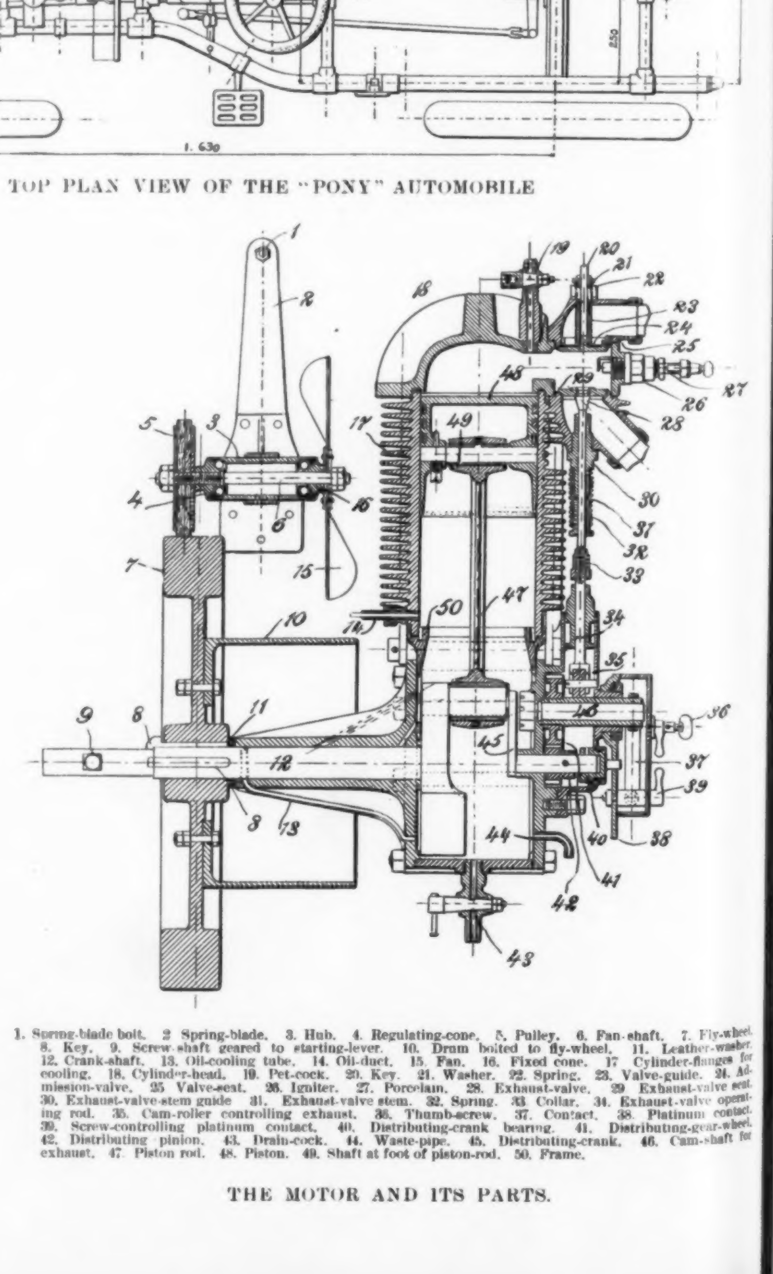
TOP PLAN VIEW OF THE "PONY" AUTOMOBILE



THE TRANSMITTING DEVICE.



SPEED-CHANGING AND TRANSMITTING GEARS.



1. Spring-blade bolt. 2 Spring-blade. 3. Hub. 4. Regulating-cone. 5. Pulley. 6. Fan-shaft. 7. Fly-wheel. 8. Key. 9. Screw-shaft geared to starting-lever. 10. Drum bolted to fly-wheel. 11. Leather-washer. 12. Crank-shaft. 13. Oil-cooling tube. 14. Oil-duct. 15. Fan. 16. Fixed cone. 17 Cylinder-flanges for cooling. 18. Cylinder-head. 19. Pet-cock. 20. Key. 21. Washer. 22. Spring. 23. Valve-guide. 24. Admission-valve. 25 Valve-seat. 26. Igniter. 27. Porcelain. 28. Exhaust-valve. 29 Exhaust-valve seat. 30. Exhaust-valve-stem guide 31. Exhaust-valve stem. 32. Spring. 33 Collar. 34. Exhaust-valve operating rod. 35. Cam-roller controlling exhaust. 36. Thumb-screw. 37. Contact. 38. Platinum contact. 39. Screw-controlling platinum contact. 40. Distributing-crank bearing. 41. Distributing-gear-wheel. 42. Distributing pinion. 43. Drain-cock. 44. Waste-pipe. 45. Distributing-crank. 46. Cam-shaft for exhaust. 47 Piston rod. 48. Piston. 49. Shaft at foot of piston-rod. 50. Frame.

THE MOTOR AND ITS PARTS.

[Continued from SUPPLEMENT, No. 1346, page 21569.]

THE PHYSICAL CONDITION AND SAFETY UNDER PRESENT LOADS OF THE NEW YORK AND BROOKLYN BRIDGE.*

EXCESSIVE STRESSES IN CABLES AT THE CENTER HINGE OR SLIP-JOINT.—This is the most serious cause of danger in the bridge. Our calculations show the maximum stresses to be, if no account is taken of the loads borne by the stay system:

	Lbs. per sq. in.
From fixed and moving loads.........	44,800
From bending of cable as a whole......	28,600
From bending of individual wires......	2,000
Total............................	75,400

The stay system does carry some of the loads, though it is impossible to say how much, since the original adjustment has been changed by the failure of the bottom chords in 1898. It is believed that if the stresses in the cable from fixed and moving loads are assumed to be reduced 10 per cent because of the help afforded by the stays, an ample allowance will have been made. The strength of the stay system is greatly reduced by the weakness of its end connections, in which failure would occur long before the strength of the ropes is reached. If the 75,400 pounds per square inch stress above be reduced by the amount which may perhaps be eliminated by the stays, the stress in the cables from above cause is 71,000 pounds per square inch. This is about 18 per cent in excess of what we regard as the permissible working stress, 60,000 pounds per square inch. This stress of 71,000 pounds is, however, increased by the wind pressures, but to what extent is not yet known. The condition, therefore, is a very serious one—that of a stress in the cables much above the safe limit, but with its exact amount unknown.

Means by which the stresses in cables due to bending may be largely reduced are described in Appendix D. They consist in removing the wrapping from cables for a few feet at each slip-joint and using sleeves at these joints to fix the least radius in which the cables can bend. We believe that by these means the bending stresses may be reduced to one-fifth or less of their present amount, and that the work will entail no serious interruption to traffic, can be completed within three or four months after the money is available, and at a cost of perhaps $30,000. No estimates have been made, however, and the time and cost given are merely guesses. It should be added that the full maximum stress in the cables cannot occur at present, as the hottest weather is one of the conditions necessary to produce it.

WIND STRESSES IN CENTER SUSPENDERS.—The transference of the wind pressures from the trusses to the cables through these rods causes bending in the rods, and we believe this cause alone is sufficient to account for their failure. A new design should be adopted by means of which tension only would occur in the suspenders. The wind pressures should be transferred from floor to cables by a separate detail. In the meantime any serious results from their possible failure may be guarded against by frequent inspections.

EXCESSIVE STRESSES IN MASONRY OF TOWERS.—The maximum pressure existing in the masonry of the towers, with saddles immovable as at present, is (neglecting wind pressure) at least 39.6 tons per square foot. The exact amount is uncertain and may be considerably more. The working stress should not be more than 20 tons per square foot. Even this is generally considered a high value. Making the saddles movable would reduce the maximum pressure to about 35 tons per square foot, and would diminish the present uncertainty as to the exact amount; it would, at the same time, however, increase the stresses in the cables from bending, already too high and not accurately known.

A means has been suggested in Appendix F and shown in outline in Fig. 1 by which the pressure in the masonry can be reduced to about 25 tons per square foot. It would at the same time reduce the stresses in the cables and anchorages to an extent sufficient to permit strengthening the floors and increasing the moving loads by relaxing the restrictions on spacing of trolley cars, without harm to the bridge from the resulting additions to its weight. This improvement consists in strengthening the stay system, releasing the saddles from their fixed positions and adding anchorages under each shore span, as shown in Fig. 1. The idea of the anchorage itself is an old one, having been suggested for the design of this bridge and being a feature of one of the designs for a bridge over the Hudson River; some of the features accompanying it here we believe to be new, however.

EXCESSIVE STRESSES IN FLOORS.—Main floor beam: The actual stress in the chords is 15,500 pounds per square inch, and the working stress should be only 14,000 pounds. The larger stress is, however, the result of increase in the loads and not of defects in the design. The stress can easily be reduced to the desired working stress by increasing the length of the cover plates.

Intermediate Floor Beams of Railroad Tracks: The actual stress is 27,000 pounds per square inch, and should be only 14,000 pounds. The excess is due partly to defects in the design and partly to increase in loads.

Intermediate Floor Beam of Roadway: The stress is 23,000 pounds per square inch, and should be only 14,000 pounds. The wheel loads have not been increased.

Channels Supporting Intermediate Floor Beams: Those along the outer high truss have stresses of 34,000 pounds per square inch, and those along the inner high truss 17,000 pounds. The excess is due partly to design and partly to increase in loads. The working stress should be only 14,000 pounds.

Wooden Stringers of Railroad Tracks: These have actual stresses of 1,750 pounds per square inch, and should have only 1,300 pounds. In cases where the joints come between floor beams the stringers have still less strength and most of the wheel load must be carried by the rail. This is extremely bad practice.

Planks of Roadways: Those below trolley wheels have 3,140 pounds stress, and those below wagon wheels 1,550 pounds. The stress should not be more than 1,300 pounds. In neither case have the wheel loads been increased.

If the improvement of stay system is made, so that the dead weight of bridge may be safely increased, all of the above defects can be easily remedied. While we have made no plans or estimates and the statement is merely a guess, we think that the entire improvement can be made at a cost of from one-half to three-quarters of a million dollars, and within less than three years' time. The necessary calculations are very intricate and difficult, and it might take all of the first year to make the survey of the structure, finish the computations and complete the plans. Nothing has been said as to the safety of the anchorages. Our computations show them to be amply safe. Their factor of safety against sliding is 2.45 with the present loads, while ordinary practice requires only 2.

Before closing, we shall very briefly repeat our conclusions, as follows:

We find that some deterioration of the bridge has been allowed to occur because of improper supervision and inspection, but that at present (because of repairs) no important deterioration exists and that the structure is practically as strong now as when completed.

Its safety, however, due to increases in the moving loads, is less than when the bridge is completed, and, because of defects in the design, has never been so great as was supposed and is now much below the degree considered good practice for ordinary bridges.

We believe the present margin of safety to be so small that the necessity for repairs is very urgent, and have suggested means by which the safety can be largely increased without materially interfering with the traffic and at a comparatively small cost.

We believe the present methods of supervision, inspection and maintenance to be very faulty and not such as will with any certainty keep the bridge in a safe condition.

APPENDIX A.—THE ACCIDENT AND ITS CAUSES.

The accident to the New York and Brooklyn Bridge which was the cause leading to your inquiry into the safety of the structure was the discovery on the evening of July 24, 1901, that seven suspender rods and two cable bands had broken. These nine broken suspender connections were consecutive in position and were located at the middle of the river span on the northernmost cable.

An examination of one of the broken cable bands showed that the fracture was recent and sudden throughout the whole section. About 50 per cent of the fractured area was coarsely crystalline, indicating (for this particular band, at least) a poor and untrustworthy quality of metal.

All the broken suspender rods had been passed through the fire before our appointment to remove the nuts and to weld new ends to the broken rods so they could be reused in the bridge. This heating of the rods renders their subsequent examination of little value in determining the age of the breaks. The examination did show, however, that in some cases, at least, the breaks had been gradual and that a zone through the middle of rod had broken last.

It is stated by the engineers of the bridge, who had opportunity to examine the broken pieces before they were heated, that two of them had been broken for a long time. It is said that these two were the two in the middle of span, next on each side of the slip joint. It is also said that most of the other rods showed evidence of gradual failure, and that one, near an end of the broken group, showed a new, sudden fracture throughout its whole section; also that the two broken cable bands, which were sudden fractures, formed the two ends of the broken group. A careful study of the subject convinces us that the following causes all contributed to the failure of there rods:

(1) TEMPERATURE STRESSES.—The temperature stresses are much larger in summer in the suspenders near the middle of the river span than in any others. This is due to the angle which must be formed in the cables near the sliding joint, which angle (or sharper curvature) can exist only because of the vertical pull on the cables being greater there than where no angles are to be found.

It is estimated in Appendix D that the extra stress coming on each of the eight middle suspenders from this cause is nearly nine tons, with the saddles immovable, as at present, and that it was still larger before the saddles ceased to move. The stress coming on each ordinary suspender from dead weight and moving load is about twelve tons, which is reduced to about eight and one-quarter tons for the middle suspenders by the closeness together of the two middle floor beams. As the temperature stress in the ordinary suspenders is very small, the combined stress from loads and temperature will be about seventeen tons for each middle suspender and about twelve tons for each of the others.

(2) RODS NOT VERTICAL.—All stresses in the middle suspender rods are increased by the want of verticality of the rods during extremes of temperature. On some of the cables the middle rods are only 16 inches long, while (even if well adjusted) they may be as much as 3½ inches out of the vertical, the increase of stress because of the inclination being in this case nearly 3 per cent. The increases of stress in the middle rods already mentioned are pure tension. While they are of considerable importance, the strength of the rods (118 tons breaking strength each) is ample to withstand them, and they are probably unimportant in comparison with the stresses which are produced by the side bending, as described below.

(3) FRICTION OF TRUNNIONS.—The force necessary to overcome the friction, especially when trunnions are unlubricated, is certain to cause large bending stresses in the rod, and the one trunnion taken apart was found to resist motion by a side bearing as well as by axle friction. These bending stresses will be much more sudden, frequent and harmful from the passage of moving loads across the bridge than from the slower temperature changes, but their amounts are hardly computable.

(4) BENDING TRANSVERSE TO BRIDGE.—All the rods which have been used to replace those which failed are bearing against the up-stream edge of trunnion holes at top, showing that there is a constant bending stress in these rods transverse to the bridge. This bending stress must be increased suddenly at each passage of moving load.

A very important cause of side bending is wind pressure. The wind pressure on the structure produces a lateral deflection of the stiffening trusses. The stiffening trusses of the two halves of the span will after deflection form an angle at center hinge and the cables connected to them will form a bend. A large part of the wind pressure on trusses and floor is transferred at bend to the cables by means of the suspenders. The amount of wind pressure transferred by these suspenders is dependent on the horizontal curve of stiffening trusses and their angle with each other at the slip joint, and could be calculated if sufficient time were available.

In a design made by us for a projected Hudson River bridge which has center hinges, and is in this respect similar to the Brooklyn Bridge, the force transferred to cables at center has been calculated and special provision has been made for its transference. We therefore know that the wind pressure to be transferred to cables at center of bridge is large, though we have not calculated its actual amount in this case. Whatever its amount, it must be transferred by the suspenders at center. The consequence is an excessive bending stress in these suspenders, which we regard as the most important cause of their failure. An entire change in the design is necessary to transfer this wind pressure safely.

All of above causes for excessive stress on the middle suspender rods are inherent in the design, and in only one case—(3)—can the stresses be lessened by careful maintenance. A thorough and frequent lubrication of the trunnions should reduce the stresses arising from (3) to a very small amount. Such a lubrication was contemplated by the designer of the trunnions, and could be quickly and easily made by drilling a small hole over each trunnion. If the proper oil or grease were used, perhaps with the addition of graphite, the application would not need to be made very often. The trunnions show no sign of lubrication, and the one taken apart was fixed tightly in the plates by rust and paint.

RODS NOT UPSET.—When compared with present standards, the whole design of the suspender connections must be considered as unsatisfactory. In one respect, however, even without changing the other unsatisfactory features of the design, the suspender connections can be easily and greatly improved.

The rod suspenders and the stirrups for wire suspenders are all made from rods not having upset ends, thus placing the weakest part of the rod—the threaded portion—where it is inaccessible to inspection and painting and yet especially exposed to the conditions causing rust. The strength of the $2\frac{1}{2}$-inch diameter suspender rods with ends not upset is only about two-thirds that of its full section, and only equal to that of a 2-inch diameter rod, with its ends upset; but the latter, while of the same total strength, has its weakest section in the body of the rod, where failure, should it occur, will be in full view and where the rod will be perfectly accessible to inspection and painting. Though it may not be economical to use upset ends on very short rods, the advantages they possess in this case should far outweigh the small increase in cost.

Two other points should be noted in connection with the accident. Some of the newspapers reported that when the broken rods were discovered measurements showed that the floor beams at these rods had sagged several inches at their up-stream ends, or that the cable had lifted that amount. This is manifestly impossible, as a small part of such a rise would bring the cable above the line joining the two first unbroken suspenders, and such a sag would cause the ruin of the floor beam. It is a fact, however, that the distance from cable to floor beam was and is greater at the northernmost cable than at any other, this cable being now about 7 inches higher than the others. The reason for this is apparent from the fact that for some years past the span of the northernmost cable has been longer by several inches than those of the others, thus causing the center of this cable to hang at a higher elevation. The other point to be mentioned pertains to the repair of the broken suspender rods. We were told that the rods used in the bridge to replace those that were broken were made by welding new ends to the bodies of the broken rods. These rods are said to be steel, of 75,000 pounds per square inch ultimate strength and of 45,000 pounds elastic limit. It is a common belief among engineers that welds in steel of this degree of hardness are not only difficult to make, but uncertain and not to be relied upon even when seemingly successfully made.

APPENDIX B.—THE FIELD INSPECTION; METHODS AND RESULTS.

The field inspection of the structure, as already stated, was begun on July 27. From that date to August 9, inclusive, a part or the whole of every day was devoted to it by one of us, only such time being used elsewhere as was necessary to collect data for the computations of strength. Since August 9 several additional days, at disconnected times, have been given to the inspection, which was finally completed on August 28.

The date fixed by you for the completion of this report, even though advanced somewhat beyond the time you yourself wished, seemed to us very short for such an important work. The work consisted, in addition to the field inspection, of the collection of data in regard to the structure and its loads, of calculations to determine its strength and safety, and of the writing of the report; and no more time could be devoted to any one of these divisions than would allow of all of them being completed by the time specified. The restricted time which could be given to the field inspection made it necessary to abridge this in some respects from what it would otherwise have been.

RIVETS.—The principal omission was that but a few of the rivets were tapped and examined for tightness. There are an immense number of them, and many in the floor could have been reached only by the use of a scaffold and a small gang of men to move it, making

* Report by Edwin Duryea, Jr., M. Am. Soc. C. E., and Joseph Mayer, M. Am. Soc. C. E., to Eugene A. Philbin, District Attorney, New York City.

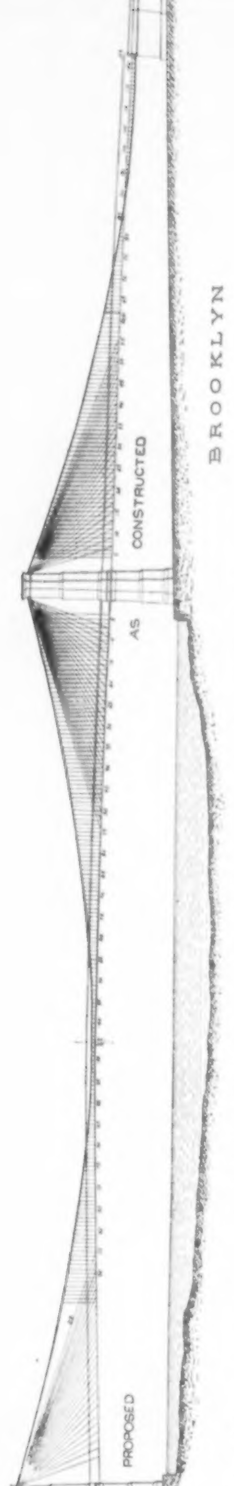


FIG. 1.—PRESENT AND PROPOSED ARRANGEMENT OF OVER-FLOOR STAYS ON THE BROOKLYN BRIDGE.

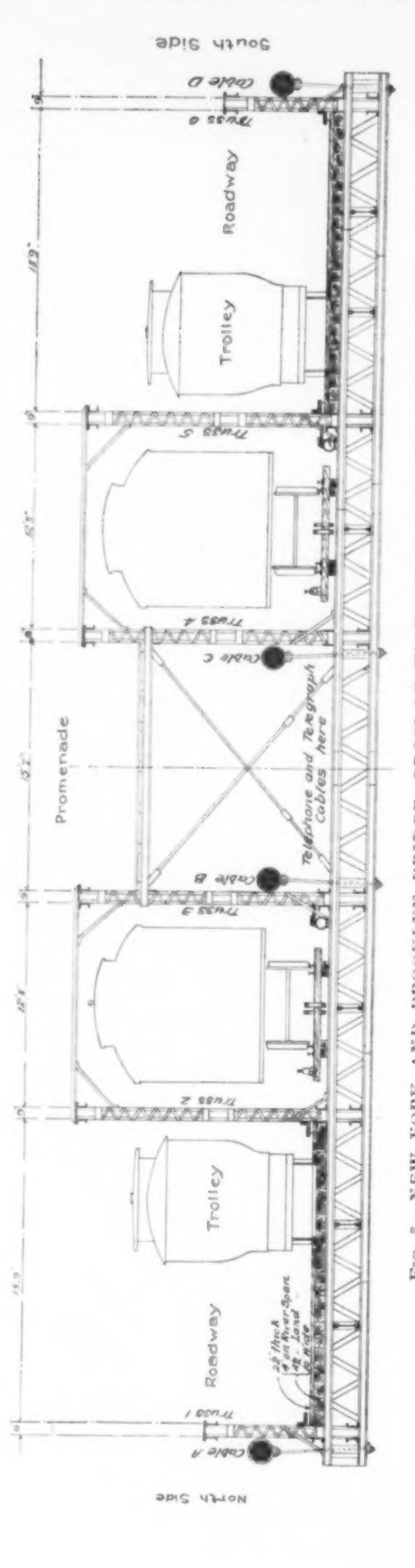


FIG. 5.—NEW YORK AND BROOKLYN BRIDGE—CROSS-SECTION NEAR CENTER OF MAIN SPAN.

FIG. 2.—DETAILS OF ONE OF THE HINGED JOINTS, SHOWING WORN CONDITION OF TRUNNION-BLOCK WEARING SURFACES, AND FRACTURE OF SUSPENDER BY BENDING.

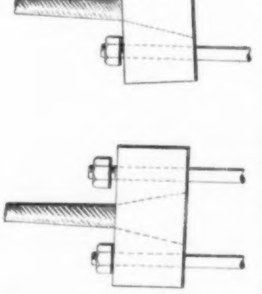


FIG. 4.—FAULTY ADJUSTMENT OF STIRRUPS.

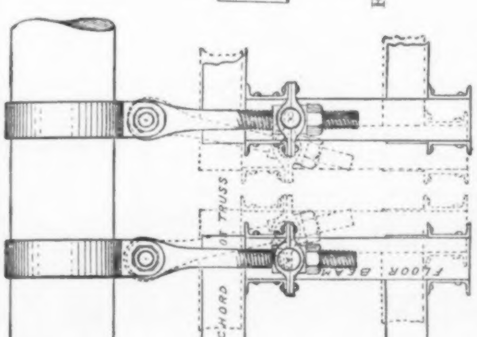


FIG. 3.—SKETCH SHOWING, IN DOTTED LINES, MAXIMUM HORIZONTAL MOVEMENT OF TRUSSES DUE TO SUMMER HEAT AND MOVING LOADS.

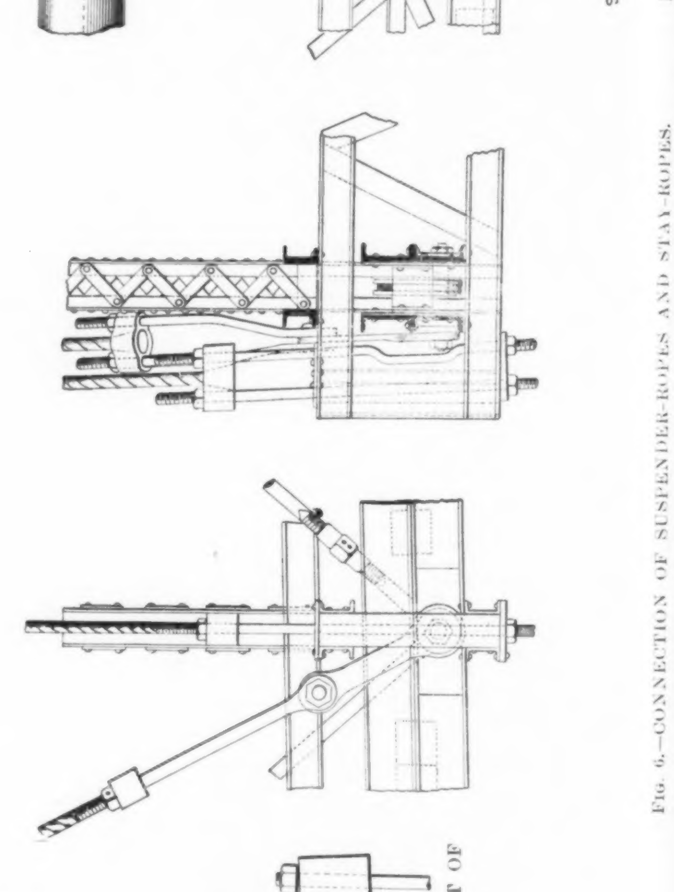


FIG. 6.—CONNECTION OF SUSPENDER-ROPES AND STAY-ROPES.

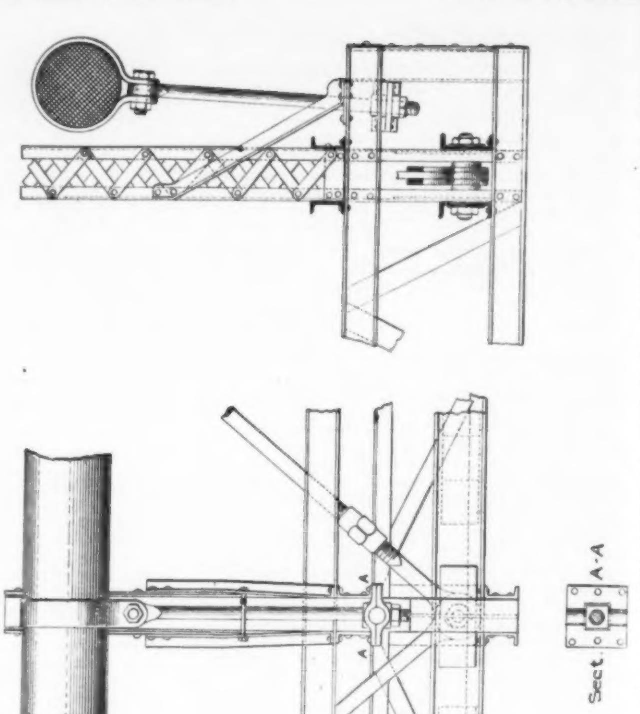


FIG. 7.—SUSPENDER RODS NEAR CENTER OF MAIN SPAN.

it impracticable to cover their complete inspection within the time available. Those which were tested, however, were found tight and in good condition, giving us some reason to suppose that the untested ones were likewise. The testing of all other parts of the structure was done as thoroughly as there can be any necessity for. It was done in person, not through assistants, and was such as enables us to speak with confidence of the present physical condition of the bridge. As the safety of the bridge lies mainly in its suspenders, cables, and towers, and is less influenced by the stiffening trusses—also because the failure of July 24 occurred in the suspender system—the inspection was directed principally to the cables and suspenders, and to their connections.

Cables.—The strands of each cable were examined by eye in each anchorage, up to the point where the anchor bars are imbedded in the masonry. They were all found dry, well painted, and in good condition, with no influences which should tend to cause deterioration. The cables were also examined by eye at practically all points between the anchorages. Where the cables were high, this was done by walking up and down the two middle cables, through the tops of the towers, and observing the cable under foot and the adjoining ones. Though this examination was necessarily a surface one only, it showed all parts of the cables to be well painted and presumably in good condition. At a single place, near the middle of river span on Cable B, A being the northernmost cable, a break about one-eighth inch wide was observed in the paint and cable wrapping, through which the straight wires of the cable showed with their galvanizing in perfect condition. Toward the anchorages, however, where the main floor beams are above the cables and are supported by means of struts or posts resting upon the latter, the foot of each post hides a short length of cable so that it cannot be examined. It is possible, though not probable, that rusting may have occurred in the cables at such points. Even if this were the case, the section of cables at these points is larger than necessary, as the stress here is less than at the towers. The cables were also examined where they pass through the tops of the towers and were all found to be dry, well painted, and in good condition.

Saddles.—The saddles, however, in which the cables lie, and which were intended to move back and forth in the direction of the bridge to allow an adjustment of the bridge to the different conditions of temperature and moving load, were found practically fixed and immovable. This immovability of the saddles causes a slight bending of the towers, and raises the maximum compression in the masonry, already much greater than is considered good practice, to a still higher amount.

Masonry of Towers.—Our computations show the tower masonry to have been exposed to what most engineers would consider a very excessive stress ever since the bridge was completed. A careful examination of the parts under greatest pressure, however, though made with a powerful marine glass from a distance of only 10 to 20 feet, shows no visible signs of deterioration. Inquiry also showed that no trouble had ever been had with the pointing mortar between the stones at the places where the greatest pressure occurs and that this pointing has never been replaced since the completion of the bridge. Both report and appearance indicate that the masonry is of an excellent quality and able to bear with safety as great a pressure as it would ever be considered safe to use in the main body of granite masonry. The fixedness of the saddles and its effect upon the masonry are treated more fully in Appendix D. It should be added that while the saddles were intended to be movable by the designers, and that while the fixed condition of saddles increases the stress in the tower masonry, our computations show that this fixedness causes a decrease in the very large secondary stresses in cables at the center of main span.

Suspenders and Stays.—The suspender system was inspected with great care, as some features in its design make it peculiarly liable to rust influences and to the development of large secondary stresses. Every wire suspender and wire stay in the bridge was tested by shaking to ascertain whether it actually had tension in it; each rod of every suspender stirrup and of every stay stirrup was tested by visual examination and by blows of a hammer for tension, bearing of nuts, condition of paint, etc.; and all the rod suspenders were examined by eye and (with a very few exceptions) by blows of a hammer.

The general condition of the suspender and stay systems was found to be good. In a few cases, however, due to careless adjustment, the stress in the wire suspender was found to be all borne by one rod of the stirrup or to be producing, because of eccentric bearings, a side bending on both rods. These cases are more fully described in Appendix C. A new rod suspender used to replace one of the broken ones was found to be under no stress whatever, being so loose that it could be turned by the hand. Such cases were reported to the Bridge Department for remedy soon after their discovery.

Suspender Stirrups.—The conditions tending to produce rust of the suspender stirrups were in many cases very bad, as described more fully in Appendix C. They consisted briefly in the presence of an inch or two of road sweepings a short way above the lower nuts, and of the upper nuts having been turned down a short distance without a subsequent painting of the thread left exposed above the nut, thus making the admission of water into the nut a possibility. At our request two suspender stirrups were taken apart for examination. They were found to be in perfect condition within the nuts, the threads there being as bright as new, but to have been reduced about 1-16 inch in diameter by rust at points below the upper nuts and above the lower nuts, or to about 90 per cent of their strength when new.

Rod Suspenders.—One of the rod suspenders near the middle of the main span was also taken apart to allow an examination of the rod and of the parts of trunnion at its lower end. It was found that the rod within the trunnion had been reduced about 1-16 inch in diameter by rust, or to about 94 per cent of its strength before rusting. The threads within the nut were bright and unrusted. The trunnion showed no signs of lubrication. The lower trunnion plate was very rusty, while the upper was much less so, and showed signs of a slight motion of the trunnion. The main resistance to rotation, however, came from an end bearing (of the cubical block forming the middle of trunnion) against the trunnion plates, as in the sketch, Fig. 2, which shows the details of the hinged connection. This end bearing held the trunnion in such a tight grip that even after removing the lower plate, and while the trunnion and upper plate lay on a plank walk, blows from a spike maul were necessary to cause rotation, those from an ordinary machinist's hammer not being sufficient.

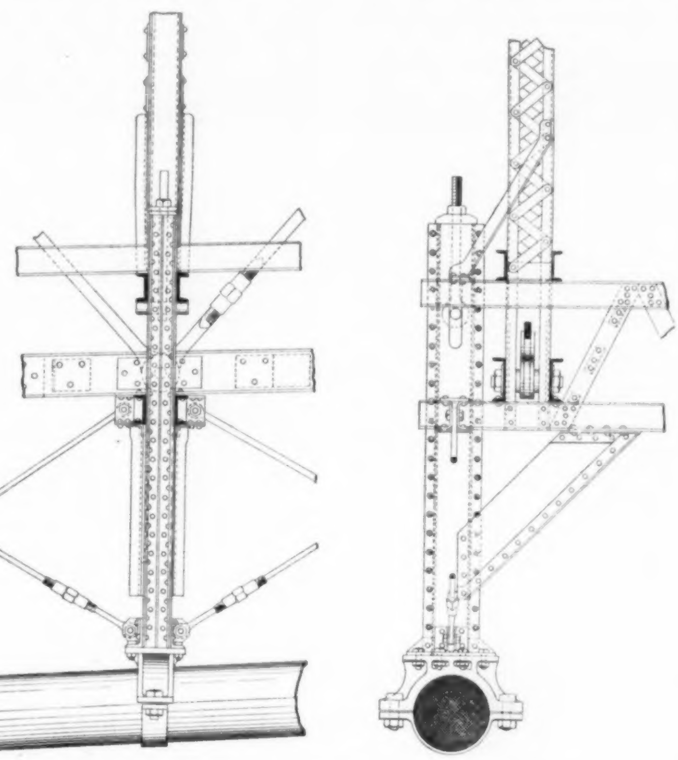


Fig. 8.—SUSPENDER STRUTS NEAR ANCHORAGES.

Suspender Ropes.—The inspection shows that many of the wire ropes of suspender system have been allowed to wear slightly, and that the wearing still continues. The floor of promenade has a motion sideways of about 2 inches from loads on one side only of the bridge, and this motion causes the plank floor of promenade to wear against many of the suspender ropes where they pass through the floor. This wearing could easily be prevented either by covering the ropes at such points or by enlarging the holes in planks through which they pass. The amount of the wearing is as yet insignificant.

Slip Joints.—The six stiffening trusses were examined for condition of paint, amount of rust, wearing of parts, etc. The examination shows that all the slip joints at middle of river and land spans are working well and are sensitive to the action of moving loads. Though unlubricated and unsightly from rust, the joints are working well without lubrication, and the only harm which has resulted from the rust is to the appearance of the structure. It may be well to say, in view of the many statements lately made in newspapers as to the harmful influence of rust on the bridge, that examination shows the structure to be in general unusually well painted (at least so far as it can be visible to the critics), and to be quite free from harmful rust.

Rust Conditions.—The conditions tending to produce rust are bad in some cases, however. Those in connection with the suspender stirrups have been already mentioned, also the fact that not much weakening seems to have resulted from them as yet. The examination showed that the conditions tending to produce rust have been very bad in the case of the bottom chords where they pass through the towers and of the bottom chord pockets at slip joints of end spans. As more fully described in Appendix C, several inches of water or mud were found standing in many of the bottom chords at these places, due to the drainage holes having been allowed to fill up with dirt. At our request the water and dirt were removed so that an examination could be made for possible rusting. In the course of the cleaning several new drain holes were drilled, giving good opportunity to see the section of the metal, but the subsequent examination failed to show that rusting had resulted to a harmful degree.

Diagonal Bars Worn.—The inspection shows that the diagonal bars of the four high trusses have been worn by rubbing against each other and against the posts at intersections. In most of the bars so affected the wear now amounts to about 1-16 inch, or to about 10 per cent of the section of the thinner (double) bars, while in a few cases the wear is more, perhaps as much as ⅛ inch. It is estimated that about one-third of the diagonal bars in the four high trusses are so affected, and the wearing is still in progress. Though the strength of the bars is somewhat reduced by this wearing, probably to a greater degree than the loss of section, the strength of the truss is not, as these bars still have an excess of section. The wearing can easily be prevented, however, by protecting the bars with sheet metal or some similar material at intersections.

Sway Rods Worn.—A similar wearing was found in many cases at the intersection of the sway rods connecting the two middle trusses together, beneath the promenade. This also has had as yet no serious effect on the strength of the structure as a whole.

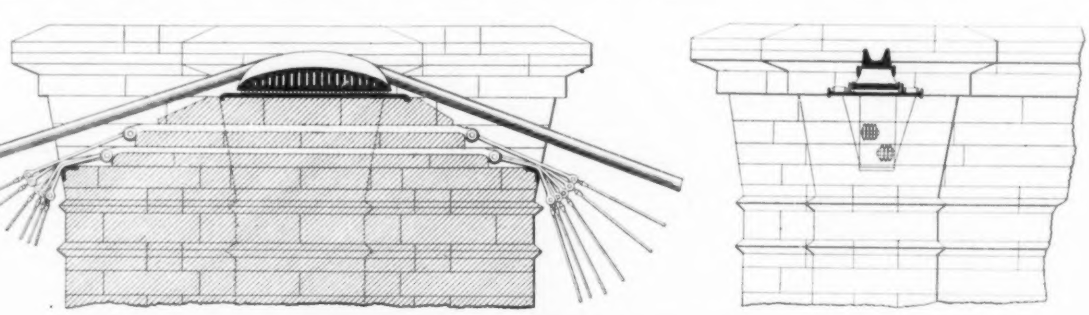


Fig. 9.—SADDLES AND TOP OF TOWER.

Tracks of Bridge Railway.—One of the most serious features observed during the inspection is neither the result of deterioration nor directly a question of strength. The tracks used by the bridge trains are laid on 5 by 7-inch ties spaced 17 inches apart in the clear and with no guard rails or tie spacers used in connection with them. The drawings furnished us show two wooden guard rails and the ties spaced 8 inches apart in the clear, but the changes are said to have been made when the gauntleted tracks were placed on the bridge.

The most careful practice in bridge floors by American railroads is to space the ties 4 inches apart in

Fig. 7.—SUSPENDER RODS NEAR CENTER OF MAIN SPAN.

Fig. 6.—CONNECTION OF SUSPENDER-ROPES AND STAY-ROPES.

MOVING LOADS.

the clear and use four guard rails, and the least provision (at least on reputable railroads) is to use an 8-inch spacing and two guard rails. The most common provision is probably a spacing of 6 inches and two guard rails. The ordinary practice of the elevated railroads of this city is to use four guard rails and a spacing of 4 to 6 inches.

The low speed of the bridge trains (that of the cables is only 11.3 miles per hour) and the fact that most of the trains are hauled by cable makes the probability of derailment much less than is the case with trains hauled at high speeds by steam locomotives; and the low speed and absence of heavy locomotives makes the damage which would probably result from a derailment much less. Notwithstanding these considerations, however, the bridge tracks in their present condition seem to us to subject the structure to very unwarranted risks in case of derailment, and the tracks should, in our opinion, be modified by making the clear distance between ties only 6 inches and by the addition of two guard rails dapped over ties.

APPENDIX C.—WAYS IN WHICH THE BRIDGE HAS BEEN ALLOWED TO DETERIORATE FROM LACK OF PROPER INSPECTION AND MAINTENANCE.

Stirrup Rods Allowed to Become Improperly Adjusted.—Some of the stirrup rods of wire rope suspenders were found to have been readjusted carelessly, so as to cause either eccentric or unequal and eccentric pulls in the two rods forming stirrup. This unequal or eccentric pull was caused merely by screwing down the two nuts on top ends of stirrup rods unequal amounts, so as to throw all the bearing on one rod or on the edges of the two nuts (Fig. 4).

In the first case the available strength of the stirrup is reduced to about one-twentieth and in the second case to about one-fifth of what it would be with full and equal bearings on the two nuts. Eccentric stresses are also caused in the wire rope where it enters the cast socket.

This faulty adjustment was noted by specific position numbers in about 20 places, and about as many more cases were seen but not specifically noted. As the total number of wire suspenders in the bridge is 1,096, the proportion having their available strength largely reduced by faulty adjustment is certainly not great. In many cases, however, the faultily adjusted suspenders were found near (not next) each other, in groups of two or three, giving a weak spot in the suspender system, in which failure would occur under much less stress than in the well adjusted portions, and from which it would then tend to spread to the adjacent well adjusted suspenders. The faulty adjustment of suspenders therefore seems to us much more serious than is indicated by the relatively small number of cases.

This faulty adjustment is plainly evident to any ordinary conscientious visual inspection, and a failure to observe and correct it, even in the comparatively few instances found, indicates a faulty and inefficient method of inspection. In some cases the nuts had been turned down since the last painting and the unequal lengths of unpainted thread exposed above the two nuts showed plainly that previous to this careless turning down the two nuts each had full bearing.

Trunnions of Suspender Rods not Kept Lubricated.—The conditions found in the trunnion taken apart for examination are described in Appendix B, and the various forces acting on the rods passing through trunnions in Appendix A. Many of the causes tending to break these rods have their origin in the original design of the structure, and it is improbable that any amount of watchfulness and care—unless exercised in replacing these suspender connections by an improved design—could have prevented the breaking of the two middle suspenders.

One of the causes, however—the forces tending to bend the rods in the direction of the bridge—could have been very largely prevented by an efficient lubrication of the trunnions. The designer of these trunnions has publicly stated that their proportions and strength were governed by the assumption that they would act as lubricated journals. The lack of lubrication was one of the causes leading to the failure of the rods and to the interruption in the use of the bridge, and it is our opinion that this omission of lubrication may be regarded as a deterioration of the structure from a lack of efficient maintenance.

Spreading of Breaks in Suspender Rods.—While it is our belief that the breakage of the first suspender rods was mainly due to features of the original design, we also believe that the first efficient inspection after such a break occurred would have resulted in the discovery of the broken rods. A broken rod—or even one which, while not broken, has very little or no stress in it—can be detected without difficulty from its sound under blows from a hammer. The complete breakage of a rod can also be detected by the eye without waiting for the cable to rise enough to draw the fractured section above the top of the trunnion. The least lifting of the rod will break the paint film connecting the rod with the top of the trunnion, or bring into view a portion of the rod, unpainted or differently painted, which was before within the trunnion. Knowing the former condition of the paint, either or both of these changes in appearance should be sufficient to excite suspicion as to the soundness of the rod and to cause more conclusive tests with the hammer or the wrench.

The fact that two suspender rods had been broken for a long time without discovery, and that the breakage was permitted to spread until seven additional suspenders had failed, cannot be regarded otherwise than as an indication that the inspections were too infrequent or that the methods of inspection were inefficient.

Suspender Ropes Allowed to Wear.—Many of the wire suspender ropes have been allowed to rub and to wear slightly against the floor boards of the promenade floor. This has occurred only outside the limits of the stay systems. A partial count shows that about two-thirds of the suspender ropes not crossed by stays are so affected, and are still rubbing and wearing. The wear is very small as yet, consisting in only a very few cases of as much as the half of two or three wires, but could easily have been prevented entirely by binding a piece of sheet lead, tin, rubber, rubber fiber or similar material to each suspender where it passes through floor, or by enlarging the holes in the boards. The former has in many cases been done within the limits of the stay system to both suspenders and stays.

Diagonal Bars and Sway Rods Allowed to Wear Against Each Other.—The diagonal bars of the four high stiffening trusses (trusses Nos. 2 to 5) have been in very many cases allowed, at intersections, to rub and wear against each other and against the vertical posts. This action is still going on and it is estimated that about one-third of all the diagonal bars of the four high trusses are so affected. The wearing is usually about 1-16 inch, representing a loss of about 10 per cent of the original section of the thinner (double) bars, and in a very few cases a wear of about ¼ inch was found. The vertical posts are also worn slightly at the corresponding points.

The transverse diagonal rods connecting trusses 3 and 4 with each other, and lying in vertical planes below the promenade, are also in many cases rubbing and wearing where they intersect each other. The part lost by wear is generally larger, proportionally, than in the bars. The wear of both bars and rods could easily have been prevented by interposing sheet metal, rubber, fiber or similar material between the parts.

Widening the Spaces Between Track-ties and Removing Tie-spaces (Guard Rails).—The drawings furnished us show the ties spaced 8 inches apart in the clear and with two wooden tie-spaces or guard rails, and this is believed to have been the construction of the railroad floors previous to the use of the bridge by trolley cars. The ties are now spaced 17 inches apart in the clear and the wooden tie-spaces have been omitted. This was doubtless done to prevent an increase in the total loads on the bridge when the moving loads were increased by the trolley cars. In our opinion, this change in the floor subjects the structure to more danger than would have arisen from the increase in weight and is a constant menace to safety.

Continued Use of Wooden Stringers of Insufficient Strength in the Railroad and Trolley Tracks.—It seems probable that the stringers were allowed to remain unchanged when the wheel loads were increased. Whether this is the case or not they have for a long time past been strained far beyond the limits of ordinary good practice. Care has not even been taken, in the railroad floor, to keep the joints of the stringers over the main floor-beams; in such places the rail itself must be the main carrier of the load, which is a condition outside the limits of good practice. It seems probable that these insufficiently strong stringers also have been kept in use in order to prevent an increase in the weight on the bridge, in which case a somewhat remote danger has been avoided at the expense of incurring a much more probable one. The ordinary working stresses and assumptions governing the use of wooden stringers are matters of common knowledge among engineers, and there seems no reason why this bridge, carrying perhaps more passengers than any other in the world, should not be made to conform to these ordinary requirements.

Lack of Reliable Plans of Structure.—There is no complete set of plans showing fully and reliably the present features of the structure. Those which do exist are few in number, insufficient and unreliable, and, in many instances, without date. Some of them show the structure not only not as it is at present, but as it never has been. A fire destroyed part of the plans some years ago, but ample time has elapsed since to allow of their being replaced by others showing the actual construction. Efficient supervision should, in our opinion, include the securing and maintenance up to date of a complete and reliable set of plans showing the actual features of the structure; plans of sufficient completeness and reliability to allow a decision to be made from them with confidence on all questions of strength.

To the above may be added certain conditions tending to cause rust which have been allowed to exist, but which our examination does not show to have as yet resulted in any appreciable harm to the structure.

Water and Mud Allowed to Collect in the Bottom Chords of Stiffening Trusses.—No efficient provision has been made to keep water and dirt from gathering in the bottom chords where they pass through the towers, or in the pockets at the foot of end-posts at slip-joints of land spans. In the case of the latter, small drain holes exist but had been allowed to fill with dirt, while the former are supposed to have been originally self-draining but to have become clogged with dirt. There are twelve lower chords running through towers, and in four of these water was found to depths of 2, 5, 8 and 8½ inches, respectively, and nearly all contained large quantities of dirt, mostly wet horse manure. In the pockets at bottom of end-posts water was found in seven of the 24 pockets to depths of 5½, 6, 7, 7, 8, 8 and 8 inches, respectively. Dirt and mud were also found at the bearings of bottom chords on the anchorages. These bad conditions could have been prevented at any time since the completion of the bridge by providing large drain holes which could not become clogged by dirt, filling such places with concrete so that the water and dirt could not enter, or by some similar means.

Sweepings Around Base of Suspender-stirrups.—In practically all cases of long stirrups to wire suspenders of cables A and D, the sweepings (mainly horse manure) from the floor have been allowed to accumulate to a depth of 2 or 3 inches in a pocket at the bottom of the floor-beam around the bottom of the outer rod of stirrup. Similar accumulations were observed in a few of the rod-suspenders of end-spans. The sweepings show wet after rains and cause a condition favorable to rusting, but the removal and examination of a single rod showed no appreciable rusting in that case. The bad condition can be removed, however, by using board covers to prevent the collection of sweepings in these pockets.

Threads of Suspender-stirrups not Painted Above Nuts.—In very many instances (probably over one-third of the wire suspenders) the two top nuts of the stirrups connecting suspenders to floor beams have been turned down from ¼ inch to ½ inch, and the thread thus left exposed not since painted. This would seem to permit a more or less free access of water into the nut along the thread and a possible rusting of the thread. In very many cases blows of a hammer on the stirrup-rods shook down rust (sometimes a half-teaspoonful) from within the hole in the cast block through which the stirrup-rods pass, and in one case, even, about a tablespoonful of water was jarred down from around one of the stirrup-rods. The removal of this rod, however, and of one or two others, showed that in those cases the rusting was due to the design and to influences acting from below, and not to the unpainted threads above. The possibility should be removed, nevertheless, by painting these threads.

Rust and Dirt Accumulated Under Rollers at Edges of Saddles.—Dirt, rust and paint have been allowed to accumulate under the front and rear rollers of saddles at the top of towers. It is impracticable to examine any but the end rollers, the design preventing either examination or cleaning of the intermediate ones. It would be easy, however, to keep the outer sides of the end rollers free from dirt, and this has not been done, samples having been found and taken of dirt ridges (rust, paint and dirt) ½ inch high in front of and bearing the impress of rollers. In one case, even, a steel wedge (the "plug" of a plug and feather) was found embedded in the ridge of dirt. In several cases, also, the outer rollers are badly skewed with the saddle.

Hasty observation under moving loads seems to show that the saddles are now practically fixed and immovable on the towers, with rollers not acting, and measurements made by the Bridge Department of the position of saddles show this conclusively—the saddles having the same position in summer as in winter for several years past.

This fixedness of the saddles was a condition not contemplated by the designers of the bridge. It was at first considered by us to be a serious deterioration in the safety of the structure, which view would be shared by engineers in general. Further estimates of strength, however, showed that while the cessation of motion had indeed increased the stresses in the tower masonry quite materially, it had at the same time caused a decrease in the large and hitherto unappreciated secondary stresses in the cables at the middle of the main span, so that the net effect of this stoppage of motion in the saddles is probably a benefit to the bridge.

Even had our computations shown that it is desirable to have the saddles movable, it is very doubtful if any ordinary care in supervision would have prevented them from becoming fixed. The stays passing over the saddles are in every instance bearing hard against the shore edge of the bed-plate and prevent any further motion toward the river unless slip should occur between them and saddle. In addition, the condition of the inaccessible intermediate rollers may be (and probably is) so bad as in itself to prevent motion of the saddles. The conditions observed at the outside rollers (and which were easily preventable) are, however, probably sufficient in themselves to prevent motion. In Appendix F certain changes are suggested by means of which the saddles could be made movable, so relieving the stresses in the masonry, and at the same time a reduction secured in the secondary stresses of cables.

RESUME OF APPENDIX D.

The length of Appendix D and the many separate subjects comprised in it seem to make it advisable to give in a condensed form the sequence of the various parts and principal results obtained. The bridge is composed of three systems, the cables, the stay-system, and the stiffening trusses. Since these systems are all connected to each other, they must deflect together and their deflections at any one point must be the same. This feature of equal deflections under loads and temperature changes is used to find the division of the work among the three systems, and thus, as closely as the available information will permit, to find the approximate stresses in each system.

Temperature Deformation of Unstiffened Cables.—A fall of temperature of 120 deg. F., with saddles fixed, causes a rise of approximately 3.16 feet in center of main span and of 3.18 feet in center of short span. If the saddles move without friction the corresponding rises are 4.60 feet and 1.55 feet, and the motion of each saddle toward shore is 0.34 foot.

Moving Load Deformation of Unstiffened Cables.—With saddles fixed and a moving load over whole bridge of one ton per foot, the drop in center of main span is approximately 1.10 feet and that in center of shore spans 1.12 feet. If the saddles move without friction the corresponding drops are 1.73 feet and 0.58 foot and the motion of each saddle toward river is about 0.13 foot.

If the saddles move without friction and there is a uniform moving load on main span only of 1 ton per foot, the drop in center of main span is approximately 8.24 feet and the rise in center of each shore span 6.14 feet.

If the uniform moving load of one ton per foot is on shore spans only, saddles moving without friction, the rise in center of main span is approximately 8.33 feet, and the drop in center of each shore span 6.87 feet.

The total change in elevation of unstiffened cable at center of main span, due to above conditions, loads and changes of temperature, is approximately 8.24 feet down from load + 8.33 feet up from load + 4.60 feet temperature = 21.17 feet total, if saddles move without friction. For centers of shore spans the corresponding change in elevation is 6.14 feet up + 6.67 feet down + 1.55 feet temperature = 14.56 feet.

Horizontal Pull on Towers.—If the main span is loaded with 1.3 tons per foot and each shore span with 0.65 ton per foot, and if saddles are fixed and exert no horizontal pull on towers at the same temperature with bridge unloaded, then the cables will pull toward river with a force of 1,674 tons at each tower.

If the main span is loaded with 0.65 ton per foot and shore spans with 1.3 tons per foot, the saddles being fixed and exerting no horizontal pull at the same temperature with bridge unloaded, then the cables will pull toward shore with a force of 1,283 tons at each tower.

The horizontal pull on a tower due to changes of temperature alone, for the above moving loads and saddles fixed, is 337 tons in either direction.

The total pull on tower due to above moving loads and changes of temperature is 2,011 tons toward river or 1,620 tons toward shore if the saddles are fixed in such a position that they exert no horizontal pull on the towers with bridge unloaded at mean temperature. If they exert a pull of 195.5 tons toward shore with bridge empty at mean temperature, then they will exert a maximum pull of 1,815.5 tons in either direction with above loads at extremes of temperature.

Pressure on Masonry of Brooklyn Tower.—The total pressure on the masonry of the smaller tower (Brooklyn) will reach a maximum of 39.64 tons per square foot with above moving loads at extreme of temperature, or even more unless the present positions of saddles are such as will give the least maximum pressure on the towers. The actual pressure on the masonry for above loads and temperatures cannot be determined from the information in our possession, and may be considerably more than the amount given.

Strength of Stay-system.—The calculation of the stay-system shows that the socketed stay ropes are strong enough to perform their proper function if the stays are properly adjusted. The stay ropes are, however, connected to bottom chords of stiffening trusses by bent rods of only 25.6 per cent the elastic strength of the ropes. The connection with bottom chords is also so eccentric as to increase the largest stress per square inch produced in bottom chord by one rope to 4.72 times the amount that would be produced by a centric connection. This eccentric connection was without doubt the main cause of the failure of these bottom chords in 1898.

Strength of Stiffening Trusses.—The stiffening trusses were found to be strong enough at center of bridge; also at stay-system, with the exception of the bottom chords serving as struts for the latter.

Owing to the lack of time and of sufficient drawings and data in regard to the shore spans, only the main span was calculated. The stresses are believed to be less in the shore spans, however, and the sections of trusses are supposed to be the same as in the main span

Deflection Stresses on Center Suspenders.—Computation shows the stresses in suspenders at the two center floor beams to be increased by reason of the deflection and hinge to an amount nearly 1½ times that in the other suspenders.

Secondary Stresses in Cables.—The cables, with the most unfavorable adjustment of stay-system, give a factor of safety of 3.3 if the primary stresses alone are considered. There are, however, large secondary stresses at several points of cables. The largest ones occur at center of main span and are due partly to the fact that the stress in the wires at the outside of a local bend in cables is more than in those at the inside, and partly to the fact that in each wire the stress is more at outside of the bend in the wire than at the inside. The former of these secondary stresses are reduced by the sliding of wires upon each other wherever there is a sharp bend. Their magnitude is, therefore, dependent on the amount of friction between the wires forming the cables. Since this is only approximately known, these secondary stresses cannot be accurately calculated. An approximate calculation shows that they reduce the factor of safety in cables to about 2.3.

The secondary stresses due to the bending of individual wires are of smaller size and are estimated to increase the maximum stress per square inch by about 2,000 pounds. This leaves a factor of safety of cables of about 2.25.

The secondary stresses in cables produced by wind pressure on bridge still further reduce this factor of safety. They have not been calculated because of the lack of time and of reliable drawings and data.

We have also assumed, in all our calculations, that the cables over middle half of main spans are parabolas at mean temperature and with mean load. If this is not the case, the secondary stresses may be much larger even than calculated.

The Moving Loads.—These need no special resume. They are the maximum loads probable on the bridge under the enforcement of the present regulations.

Distribution of Moving Loads Among the Six Trusses.—Computation shows that with one roadway of bridge unloaded the above moving loads may throw a load on one truss 45 per cent in excess of what was assumed in our calculation of stiffening trusses.

Unit Strengths of the Structural Materials.—This needs no resume. The selection of the working stresses was governed by the fact that the conditions on this bridge are much more nearly those of a highway than of a railway bridge.

Strength of Floor.—The floor was found defective in strength in some of its parts, and is, therefore, liable to occasional partial failures.

Necessity and Order of Improvements.—The most urgent improvement is that of the cables in the center of main span. Next in importance is the improvement of the floors and stay-system, accompanied by the introduction of auxiliary bents to diminish bending stresses in towers and stresses in cables and anchorages.

APPENDIX E.—METHODS OF BRIDGE INSPECTION IN USE ON SEVERAL AMERICAN RAILROADS.

Illinois Central R. R.—We make a systematic inspection of wooden bridges each fall, and in connection with these the iron bridges are also examined. This inspection is made by the Assistant Engineer of Bridges, accompanied by the Division officers, usually the Division Supervisor of Bridges and occasionally the Division Road Master. The bridges on the Illinois Central Lines are all under the care of the Superintendent of Bridges, who has men at work in various parts of the system, and who make examinations from time to time of bridges under their charge, making such adjustments or immediate repairs as are necessary to keep the bridges in thoroughly good order.

Michigan Central R. R.—Our bridges are inspected twice a year by engineers. Our bridge foremen also inspect them when they find time to do so, but most reliance is placed on the engineers' inspection.

New York Central & Hudson River R. R.—All bridges are inspected quarterly "by the Supervisor of Bridges, assisted by an inspector, who is usually a technical man." An independent inspection and report is also made quarterly by the Supervisor of Tracks.

Chicago, Burlington & Quincy R. R.—We make inspection twice a year of all the truss and girder bridges; these inspections starting usually in May and in October, and being made by the engineers. In addition to this, of course, the bridges are inspected constantly by the bridge superintendent, by the bridge foremen, and by the section men.

TABLE 1.—ESTIMATES OF WEIGHTS OF 1,545 FEET OF MAIN SPAN OF NEW YORK AND BROOKLYN BRIDGE, BETWEEN END SUSPENDERS.

Item.	(a) Report of W. A. Roebling, Ch. Engr., Jan. 9, 1882.		(b) From drawing No. 4651. Hildenbrand. 1881.		(c) Drawing No. 4651 "actual weight," computed in Ch. Engr's office. Aug., '92.		(d) From report of C. C. Martin, Ch. Engr., Dec 2, 1898.		(e) From Drawing computed in Ch. Engr's office. Aug., '01.		(f) From independent approx. computations checked by E. D. & J. M. Aug., '01.	
	Total, tons.	Pr. ft. lbs.	Total, tons.	Pr. ft. lbs.	Total, tons.	Pr. ft. lbs.	Total, tons.	Pr. ft. lbs.	Total tons.	Pr. ft. lbs.	Total, tons.	Pr. ft. lbs.
Suspended superstructure (steel work)	3,050	3,950	2,795	3,619	2,940	3,810	2,940	3,810	2,940	3,810	2,965	3,840
Timber flooring, tracks, etc	1,530	1,982	1,527	1,978	1,097	1,420	1,097	1,421	1,174	1,520	1,190	1,540
Total	4,580	5,932	4,322	5,597	4,037	5,230	4,037	5,230	4,114	5,330	4,155	5,380
Under floor stays (for wind)	....	....	124	161	45	58	45	58	45			
Hauling cables and line sleeves†	....	....	50	65	..	..	..*	..	31	143	110	143
Electric feeder cables and trolley arms‡	560[1]	726[1]	....	..	..	..	..*	..	34.28			
Telegraph and telephone cables	...	... ...	....	..	22.24	29	22.24	29	39.60			
Pneumatic tubes	....	....	....	..	..	..	..*	..	91.76	170	131	170
Suspenders and connections	... ...	....	158	205							178	230
Over-floor stays (vertical loads)	....	... ...	185	175	125	162	125	162	125	162	193	250
Total	5,140	6,658	4,789	6,208	4,229	5,479	4,229	5,479	4,481	5,805	4,767	6,173
Cables	1,600	2,070	1,545	2,000	1,600	2,070	1,600	2,070	1,600	2,070	1,613	2,090
Total	6,740[1]	8,728	6,334	8,203	5,829	7,549	5,829	7,549	6,081	7,875	6,380	8,263
Weight added 1892 to 1898.§	... ..	....	... ..		..	..	430*	557	..	..	.	..
Total fixed loads on main span	6,740	8,728	6,334	8,208	5,829	7,549	6,259	8,106	6,081	7,875	6,380	8,263
Moving loads: Bridge trains, 2 tracks	... ...	....	....	....	....	....	532	690	... .	....	530	686
Trolley cars, 2 tracks	....	... ...	... ..	....	....	....	425	550	... ...	.... ..	567	735
Roadways, 2	....	... ...	....	....	....	....	425	550	....	....	383	496
Promenade, 1	....	.. ....	. ....	....	....	....	580	750	...	....	464	600
Total moving loads, main span	1,380[2]	1,790[2]	1,380	1,790	....	....	1,962[3]	2,540[3]	1,962	2,540	1,944[4]	2,517[4]
Sum of fixed loads and moving loads	8,120	10,518	7,714	9,993	. .	....	8,221	10,646	8,043	10,415	8,324	10,780
Total loads on suspenders‖	6,520	8,448	6,164	7,993	...	....	6,621	8,576	6,443	8,345	6,711	8,690
On cables‖	8,120	10,518	7,714	9,993	....	....	8,221	10,646	8,043	10,415	8,324	10,790

† For bridge trains. ‡ For trolley cars. § Additional new bridge track and trolley tracks, hauling cables and sheaves, electric feed-wires and cables, trolley arms, telegraph and telephone wires and cables, and pneumatic mail tubes. ‖ Neglecting temperature loads and reduction on account of loads carried by stays and trusses.

[1] The 560 tons include suspenders, wrought and cast iron cable-bands, over and under floor stays, wire netting, railing, hauling cables and line sheaves, grate-bars, cable cross-connections, etc.

[2] No details of moving loads given for this date.

[3] The 690 pounds per foot on two bridge tracks is from 4-car trains on each track, run at 45 seconds headways, and 11.3 miles per hour = trains of 256,000 pounds each, 748 feet apart front to front. The 550 pounds per foot on two trolley tracks is from trolley cars weighing 28,000 pounds each and run 102 feet apart front to front on each track. The 550 pounds per foot on two roadways is from a continuous line of trucks on each roadway, each truck occupying 20 feet and weighing 5,500 pounds. The 750 pounds per foot on one promenade is from 50 pounds per square foot on the 15-foot width of the promenade.

[4] The 686 pounds per foot on two bridge tracks is from 4-car train on each track, run at 45 seconds headway, and 11.3 miles per hour = trains of 256,000 pounds each, 748 feet apart front to front. The 735 pounds per foot on two trolley tracks is from 8-wheel trolley cars weighing 37,500 pounds each (with 100 passengers) and run 102 feet apart front to front on each track. The 496 pounds per foot on two roadways is from a continuous line of wagons on each roadway, 1-3 2-horse at 8,400 pounds each, and 2-3 1-horse at 3,200 pounds each, each wagon averaging 20 feet long with horse. The 600 pounds per foot on one promenade is from 40 pounds per square foot on the 15-foot width of the promenade.

All fixed loads above are the average for the main span. The weights of the middle 740 feet of main span, between stay systems, are much less, the estimate for the total fixed load being 7,485 pounds per linear foot by (e), and 7,616 pounds per linear foot by (f); estimate (f) was hastily made and is believed to be somewhat too liberal.

The adopted figures for span loads, covering the whole or any part of the span, are 8,000 pounds per foot of bridge for total fixed load and 2,600 pounds per foot for total moving load; or the two combined 10,600 pounds per foot of bridge. This is believed to safely cover the maximum of the actual loads on the bridge at present, under the existing regulations.

The above loads all relate to span computations. For computing the strength of the floors the following concentrated moving loads were adopted: Railways—wheels of 11,000 pounds each, those of 44-ton grip-car; trolleys—wheels of 8,100 pounds, those of 4-wheel car; roadways—wheels of 4,000 pounds each, those of 8-ton truck; promenade—a crowd weighing 100 pounds per square foot. These loads are the largest now occurring on railways and trolleys, and are believed to be the maximum ones probable on roadways and promenade.

Attention is called to the very small total and relative weight of telegraph and telephone cables and pneumatic tubes.

Special additional inspections and reports are also made at least once each year by some outside expert engineer of each of the C., B. & Q. R. R. Co.'s eight long-span bridges over the Missouri and Mississippi rivers.

Pere Marquette R. R.—An inspection of all bridges is made once a year, and when a bridge is old or light or any weakness is suspected, special additional inspections are made. The inspections are made by the Engineer of Bridges and Buildings and his assistant engineers. The structures are also inspected by the bridge foremen and the section foremen whenever occasion arises in the course of their work.

Northern Pacific Ry.—Two regular inspections shall be made each year, as follows: First, in the month of January, by the Supervisor of Bridges for each division, of all truss and large trestle bridges. Second, in the month of September, by the Division Engineers and Supervisors of Bridges, of all bridges, culverts, waterways, etc. In addition, the Supervisors of Bridges shall at all times make such other inspections as may be necessary to insure safety.

APPENDIX F.—THE SUGGESTED IMPROVEMENT OF THE STIFFENING SYSTEM.

Our calculation of the deflection of stay-system and cables with movable saddles has shown that—if the load on stay-system changes from zero in the case of one loading of bridge to, in the case of another loading of bridge, a load on stay-system varying uniformly from 4,000 pounds per foot of bridge at end of stay-system to 9,000 pounds per foot at tower—the motions of saddles are reduced to small amounts, even if their friction is negligible.

In this calculation the moving load was assumed to be sometimes 1 ton per foot on river span with the shore spans unloaded, and sometimes 1 ton per foot on shore spans with the river span unloaded; it was always assumed symmetrical to axis of bridge. Much smaller amounts of moving load, if unsymmetrical to axis of bridge, will produce the same effect on one of the four stay-systems, but not on the center pillars, which are the weakest parts of towers. It is for this reason that the inequality of moving loads in main and shore spans, assumed for the calculation of bending stresses in towers, was taken 1,300 pounds per foot of bridge, while it was taken 2,000 pounds per foot of bridge in the calculation of stay-system.

The fixed saddles at top of towers produce increased and not accurately known bending stresses in center pillars of towers. If the saddles are made free, largely increased stresses will occur in stay-system; it is unable to carry them and should, therefore, be strengthened. This strengthening of stay-system increases bending stresses in towers.

The floors should also be strengthened, and this will increase dead loads and the stresses in cables, towers and anchorages. It would be very desirable to be able to safely remove the existing restrictions on car traffic. This would increase the moving loads, and the stresses in cables, towers, anchorages, stiffening trusses, and stay-system.

In making any or all of above changes, increase in the stresses in cables and anchorages should be avoided. It is also very desirable to reduce the bending stresses in towers. These aims can all be attained by strengthening stay-system, freeing the saddles, and introducing anchored bents or ropes near shore ends of stay-system. By the strengthening of stay-system, the cables and anchorages can be relieved of part of their present load, and will thereby be enabled to carry instead, with equal safety as at present, the increased dead and moving loads due to strengthening the floors and removing of restrictions on car traffic.

This strengthening of stay-system consists in improving the connections of present stays, introducing some new stays, and providing altogether new horizontal struts at bottom ends of stays.

The stay-system can only be made to carry more load by strengthening the cables above it, which would let down the center of main span and diminish the least clearance above the river. To avoid this, and to reduce bending stresses in towers, anchored bents or ropes should be introduced near the shore ends of the stay-system. The last stays connecting with floor near the anchored bents should run over movable saddles on top of the towers. The stays nearer the towers should be immovably connected to tops of towers. The cables should be connected with the anchored bents or ropes by ropes of adequate strength.

By these means the floor and cables near anchored bents may be kept at an almost uniform height near the lowest position which they now take at high temperature with shore spans fully loaded. If anchored ropes are used the cables and floor must be held by them at the lowest position which moving load and high temperature will produce. This might result in making the least clear height at center of main span much more than at present, which is not desirable. The calculations necessary to determine the balance of advantage for either ropes or bents cannot be made without knowing the present curve of cables, or their length. The stays fixed to top of towers should be so adjusted that at mean temperature, with half the largest moving load uniformly distributed over bridge, they carry the same load on both sides of tower. In this case their horizontal pulls at top of tower will balance. The stays which run over movable saddles at tops of towers will exert no horizontal pull on towers under any circumstances, except that due to friction of rollers; this, with good roller beds, is small.

The principal bending stresses in towers arise from change of position of preponderant moving load. An increase in moving load on main span will lower the cables of main span and increase the loads on stays. The stays running over the saddles will produce a tension in anchor bents. The cables in shore spans will rise and also produce a tension in anchor bents. If the anchor bents are 400 feet from centers of towers, if the height of stay-system at center of tower is 150 feet, and if the tension in anchor bent is T — then the pull toward river at the top of each tower is reduced through the presence of the anchor bents by

$$\frac{T \cdot 400}{150}$$

If the shore spans are loaded, the cables will fall in shore spans and rise in main span. The tension in stays running over saddles is reduced and this produces compression in anchor bent; the falling of cables in shore spans also produces compression in anchor bent. If the total compression is C, the pull at top of tower is reduced through the presence of the anchor bent by

$$\frac{C \cdot 400}{150}$$

The total reduction of variation of horizontal pull at top of tower is, therefore,

$$\frac{(C + T)\ 400}{150}$$

Most of the variation in dip of main span of cables with stiffening system absent, and most of the motion of saddles, is due to the change in dip of shore spans and the consequent change of curve of cables from anchorage to saddles. The bents near shore ends of stay-system prevent most of the change in deflection of rear cables, and reduce thereby the motion of saddles to a small part of what it would be in their absence. They perform, therefore, with the assistance of the stays connected near them and running over moving saddles at tops of towers, the major part of the function of stay-system, and that without producing bending stresses in towers. They also prevent rise of shore span, and consequent fall of main span when the latter is preponderantly loaded, more effectively than would be done by the stay-system alone, and thus prevent the reduction of least clearance above river in center of main span which would occur, in their absence, in consequence of straightening of cables over stays.

The stresses and deflections due to the introduction of these bents can be calculated with sufficient accuracy. It is, however, important that the adjustment of stays and suspenders should be made to agree with the assumptions of the calculations.

It is estimated that over six-tenths of the bending stresses in towers can be removed by the introduction of these bents, thereby reducing the largest stress per square foot in the masonry by over ten tons. The strengthened stay-system, with the anchored bents, will permit all the necessary additions to dead load of bridge which would be caused by strengthening its floors, and also the increase in moving load due to removal of restrictions on trolley cars, without producing larger stresses in any part of the bridge than are perfectly safe.

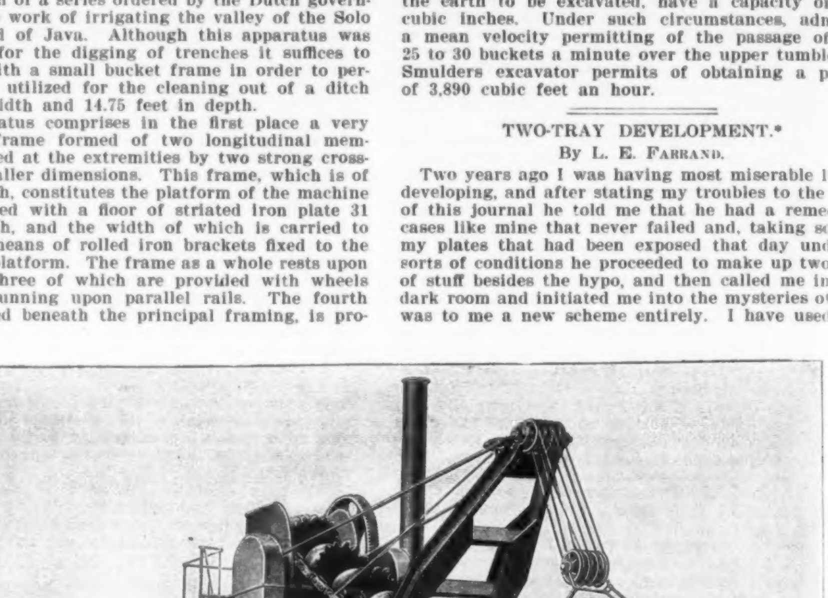
POWERFUL ENGLISH FREIGHT LOCOMOTIVE.

There is evidence of a desire on the part of the English locomotive engineers to bring their locomotives up more to the American standard of weight and power. Until very recently, no attempt has been made in Great Britain to haul a larger load than about 350 tons; but in the past year or two several companies have been building freight locomotives whose hauling capacity greatly exceeds this amount. We present an illustration of a locomotive built from the designs of H. A. Ivatt for the Great Northern Railway of England, which for the past few months has given very satisfactory service. This locomotive makes a daily round trip from Peterborough to London and back on five days of the week. On the journey from London the load averages about 560 long tons of freight, the total load, including the weight of the trucks, being 740 long tons. As the engine weighs 95½ tons, the total train load is 835 tons. The engine is of the inside-connected, eight-coupled type, while the tender is of the regulation English six-wheel type. The cylinders are 20 inches in diameter by 26 inches stroke. The length of the steam ports is 16 inches and the pressure 1½ inches, while the length of the exhaust port is 10½ inches and its breadth 3½ inches, and the lead 5-16 inch. The driving wheels are 4 feet 8 inches in diameter, with a width of tire of 5⅜ inches. The frames are of the plate-steel type and are 1⅛ inches in thickness; the distance between the frames is 49 feet 1½ inches. The boiler, which is of steel, has an outside diameter at the barrel of 4 feet 8 inches, and a length outside the firebox shell of 8 feet. The firebox, which is of copper, has an inside length of 7 feet 4⅞ inches, and an inside breadth of 3 feet 5⅛ inches, and the depth of the box outside of the tubeplate is 6 feet 3 7-16 inches. The boiler contains 191 tubes of 2 inches outside diameter. The heating surface in the tubes is 1,302 square feet, and in the firebox 136¾ square feet, making a total heating surface in the firebox of 1,438¾ square feet. The steam pressure is 170 pounds per square inch. According to our contemporary, The Engineer, to which we are indebted for our illustration and particulars, the coal consumption, when hauling full loads, is about 78 pounds per mile, or 0.093 pound per ton mile.

A NEW EXCAVATOR.

The excavator represented herewith from La Nature was constructed by A. F. Smulders, of Rotterdam, and is the twelfth of a series ordered by the Dutch government for the work of irrigating the valley of the Solo in the island of Java. Although this apparatus was constructed for the digging of trenches it suffices to provide it with a small bucket frame in order to permit it to be utilized for the cleaning out of a ditch 36 feet in width and 14.75 feet in depth.

The apparatus comprises in the first place a very stiff metal frame formed of two longitudinal members connected at the extremities by two strong cross-pieces of smaller dimensions. This frame, which is of great strength, constitutes the platform of the machine and is covered with a floor of striated iron plate 31 feet in length, and the width of which is carried to 9.5 feet by means of rolled iron brackets fixed to the sides of the platform. The frame as a whole rests upon four axles, three of which are provided with wheels capable of running upon parallel rails. The fourth axle, arranged beneath the principal framing, is provided with two small supporting wheels that rest upon a third rail so as to increase the stability of the excavator and at the same time to diminish the load upon the pillow blocks, and, on another hand, to diminish the counterpoise placed in a housing on the side opposite the bucket frame. Finally, at its front and rear extremities the frame carries traction apparatus and buffers.



GENERAL VIEW OF A SMULDERS EXCAVATOR.

Upon the platform are mounted, on the one hand, the principal framing that supports the excavator properly so called, and, on the other, four distinct steam engines, one of which actuates the bucket chain, another effects the propulsion upon the rails, the third controls the drums that serve for the loading of the cars and the fourth operates the bucket frame. These engines are supplied by means of a steam generator arranged upon the platform on one of the sides of the principal framing.

In order to prevent the accidents that might occur in case the buckets should meet with stones too large for their capacity or come into contact with material too hard for them to penetrate, the transmission of the principal engine to the upper tumbler is effected, not by gearings, but by belts. In this way, if the buckets meet with a resistance that it is impossible for them to overcome, the belts slide and no damage to either the buckets or the chain is to be apprehended. The trains to be loaded are moved forward by traction drums arranged upon the platform in such a way that they cannot be damaged by the cars.

Two rollers mounted upon a spring and placed under the bucket frame at the lower part of the bucket chain, which bears against them, increase the weight of the chain and consequently diminish shocks and oblige the buckets to pierce the resistant material that they meet with.

The buckets, which are provided with forged steel teeth that help to disintegrate the hard portions of the earth to be excavated, have a capacity of 1,100 cubic inches. Under such circumstances, admitting a mean velocity permitting of the passage of from 25 to 30 buckets a minute over the upper tumbler, the Smulders excavator permits of obtaining a product of 3,890 cubic feet an hour.

TWO-TRAY DEVELOPMENT.*

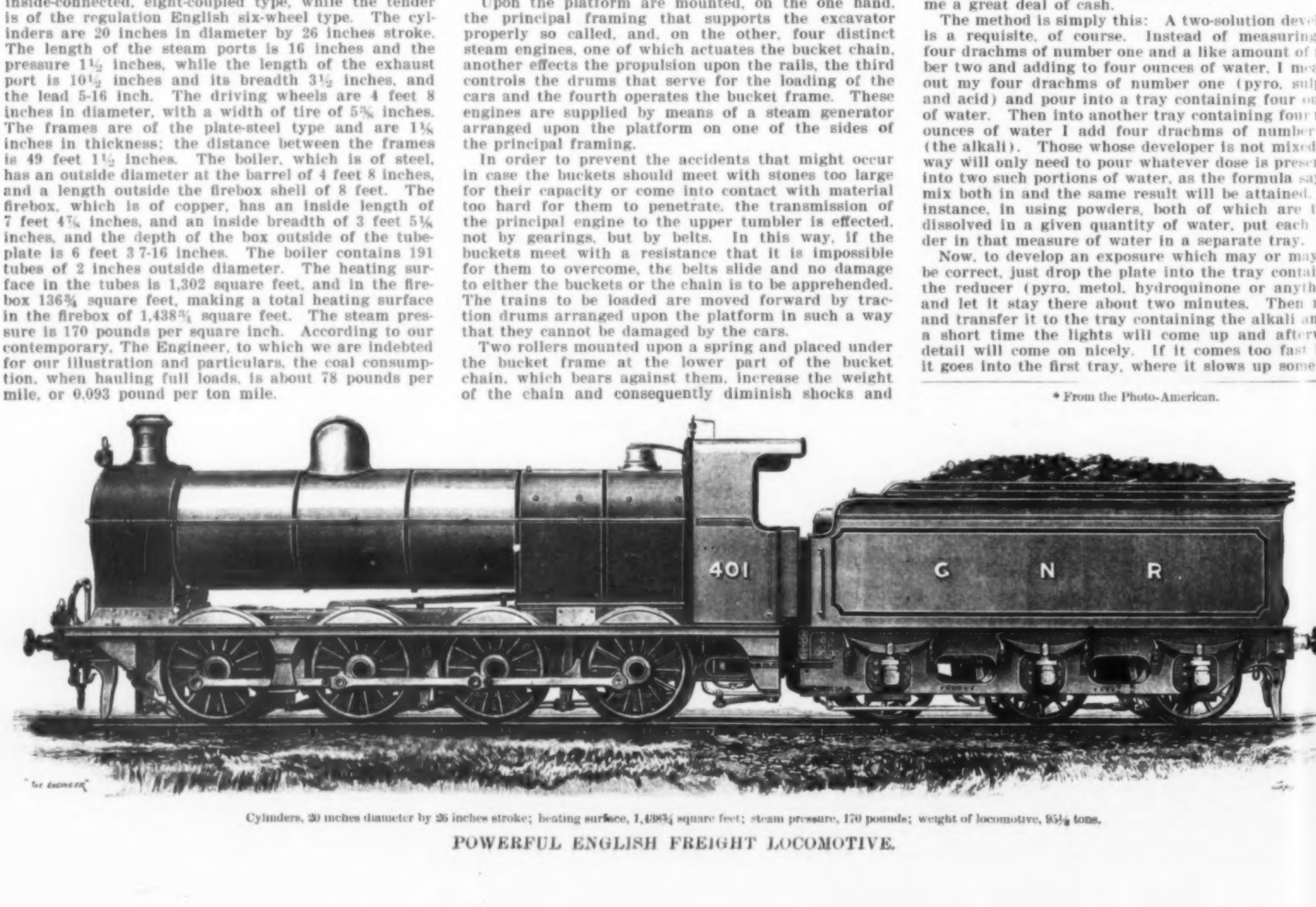
By L. E. Farrand.

Two years ago I was having most miserable luck at developing, and after stating my troubles to the editor of this journal he told me that he had a remedy for cases like mine that never failed and, taking some of my plates that had been exposed that day under all sorts of conditions he proceeded to make up two trays of stuff besides the hypo, and then called me into his dark room and initiated me into the mysteries of what was to me a new scheme entirely. I have used none other since, as I believe that for one who cannot always time his plates correctly (and I frankly confess my utter inability to do so) this is just as the editor said—the proper way to save nearly every plate exposed anywhere within reason. Certainly the method has accomplished three things for me that are pretty much everything I need—first, saved no end of plates; second, bettered my work incomparably, and, third, saved me a great deal of cash.

The method is simply this: A two-solution developer is a requisite, of course. Instead of measuring out four drachms of number one and a like amount of number two and adding to four ounces of water, I measure out my four drachms of number one (pyro, sulphite and acid) and pour into a tray containing four ounces of water. Then into another tray containing four more ounces of water I add four drachms of number two (the alkali). Those whose developer is not mixed this way will only need to pour whatever dose is prescribed into two such portions of water, as the formula says to mix both in and the same result will be attained. For instance, in using powders, both of which are to be dissolved in a given quantity of water, put each powder in that measure of water in a separate tray.

Now, to develop an exposure which may or may not be correct, just drop the plate into the tray containing the reducer (pyro, metol, hydroquinone or anything) and let it stay there about two minutes. Then rinse and transfer it to the tray containing the alkali and in a short time the lights will come up and afterward detail will come on nicely. If it comes too fast back it goes into the first tray, where it slows up some and

* From the Photo-American.



Cylinders, 20 inches diameter by 26 inches stroke; heating surface, 1,438¾ square feet; steam pressure, 170 pounds; weight of locomotive, 95½ tons.

POWERFUL ENGLISH FREIGHT LOCOMOTIVE.

gathers density. I keep this up until it is done, and so long as the plate has been sufficiently exposed it is wonderful how this method will save plates. If properly exposed we can leave it in the alkali, after a short bath in the reducer, until full detail is obtained and then transfer to the other tray until a proper density is acquired, and this in itself is a very valuable feature of the method. If in a mixed developer detail and density come on together it is not always easy to see just when we have enough of both or to get the two to act in sympathy with each other. In ordinary developer we keep on acquiring density as we develop detail out and often the density gets so much the better of the plate as to make it impossible to judge whether we have sufficient detail or not. Sometimes it is the contrary—we get a wealth of detail but cannot induce the plate to take on density. That is where this method I use is so far superior. I can govern either quality to the utmost nicety by simply transferring from one tray to another. The solutions, too, remain clear and don't stain my hands or the plate.

It is the best proposition a man ever came across for properly exposed plates, and for those whose correct exposure have to be guessed at by a greenhorn, it is the salvation of hundreds of plates that would never see the printing frame if the developer was used in the ordinary manner. For lantern slides I doubt if its equal exists. A lantern slide is a pretty delicate thing to get just right, and one finds mistakes far more numerous than could be desired. They may look all right after made, but you can't be sure till they get to the screen itself and then their quality speaks unmistakably, especially if it be bad quality. To make good slides you just get two large trays, make a dozen exposures, taking care to have them full, and drop them all in number one and then let them rest four or five minutes; that gives them the quality of qualities in slides, namely, the perfect opacity of every line no matter how delicate. Then you can put them to rinse and let number two do its work after the rinse. It is an automatic sort of way to make slides, but I can recommend it to all as one that produces a very large number of good slides with no great bother. Slides made this way are generally better than those one fusses over no end the other way, and yet it is so easy.

I wonder that this method has not been more freely ventilated in these columns. It is worth anybody's time to make a trial of it. For pictures of very light objects where the most rapid shutter may not have been quick enough for the large stop one used from choice, this is the way to save plates. For all uncertain exposures it makes them certain, and for correct timing it is all that any mixed developer could be, so why it cannot be called the ideal I do not know. It has been a great blessing to me and I feel confident that it will be to all who need such a help.

THE AUTOPLATE—AN AUTOMATIC STEREOTYPING MACHINE.

A CHAIN is no stronger than its weakest link, and this may also be said to be true of every line of business. Costly presses are of little use until the stereotype plates have been delivered to the pressman. Stereotyping has always been considered the most inexact and weakest part of the group of processes which go to make up the production of the modern newspaper. As the linotype machine revolutionized the art of typesetting, and the rotary press the art of printing with great rapidity, the "Autoplate" machine now, in turn, revolutionizes the art of stereotyping, so that for the first time in the history of the newspaper the editorial department is linked to the street by a chain of machines. The "Autoplate," as it were, sets a bridge between the composing room and pressroom, and enables the intervening space to be traversed with a degree of rapidity and economy hitherto impossible. Stereotyping in itself was one of the most important and epoch-making inventions relating to printing.

It was found that by duplicating printing forms of type by the stereotyping process it was possible to print the same edition upon a number of presses simultaneously, and indeed were this not possible under no circumstances could the large newspapers of to-day be produced.

From a single set of type forms at best but twenty-four thousand newspapers an hour may be printed, whereas by the aid of stereotyping it is possible to operate any number of presses at the same time, and have them all produce similar papers; some of the newspaper offices being so largely equipped with presses that they may turn out in the neighborhood of a million papers an hour, a fact which illustrates the importance of stereotyping.

Nevertheless, the art of stereotyping has continued to be practised in the most primitive manner, substantially all of the work being done by hand and slowly, with the result that while but little time is necessary to produce the initial set of plates for the press which is to be started first, sometimes as much as three-quarters of an hour to an hour must elapse between the starting of the first press and the completion of the plates for the last press which is to be run.

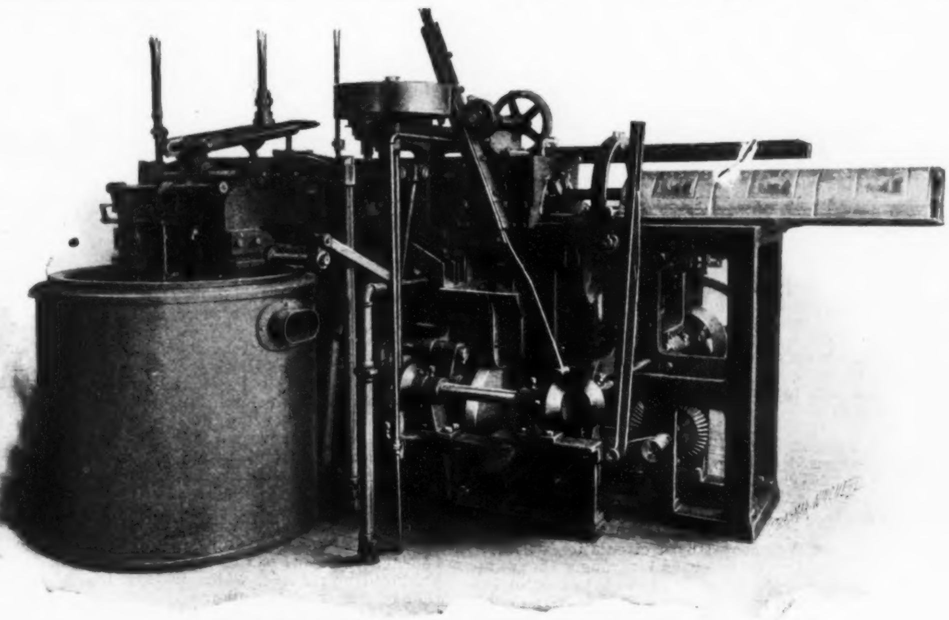
Henry A. Wise Wood, of the Campbell Company, of New York, studied the problem for several years, and at last devised a machine which, almost human in its ingenuity, is creating the greatest revolution that has ever occurred in the newspaper field. This machine enables the newspaper not only to be gotten upon the street many minutes sooner than with the old process of hand stereotyping, but enables publishers to complete the printing of their editions many more minutes earlier than heretofore has been possible.

Until the advent of the "Autoplate" machine in 1900 the art of stereotyping was practically in the same position that it was twenty years before. No stereotyping machine had been devised and hardly a tool had been improved upon, and nearly all of the operations had to be performed by hand; but the "Autoplate" has changed all this, and has made, besides a saving of time, which is of the greatest importance to a newspaper, a saving in expense and a distinct improvement in the quality of the printing plates, which are very much better and more uniform than those cast by the old process. This last feature alone is of inestimable value, for modern newspapers have grown to depend upon illustrations which are produced by the half-tone process, and the plates cast from these by the "Autoplate" machine are so far superior to those made by hand that the hand plates seem crude and coarse beside them.

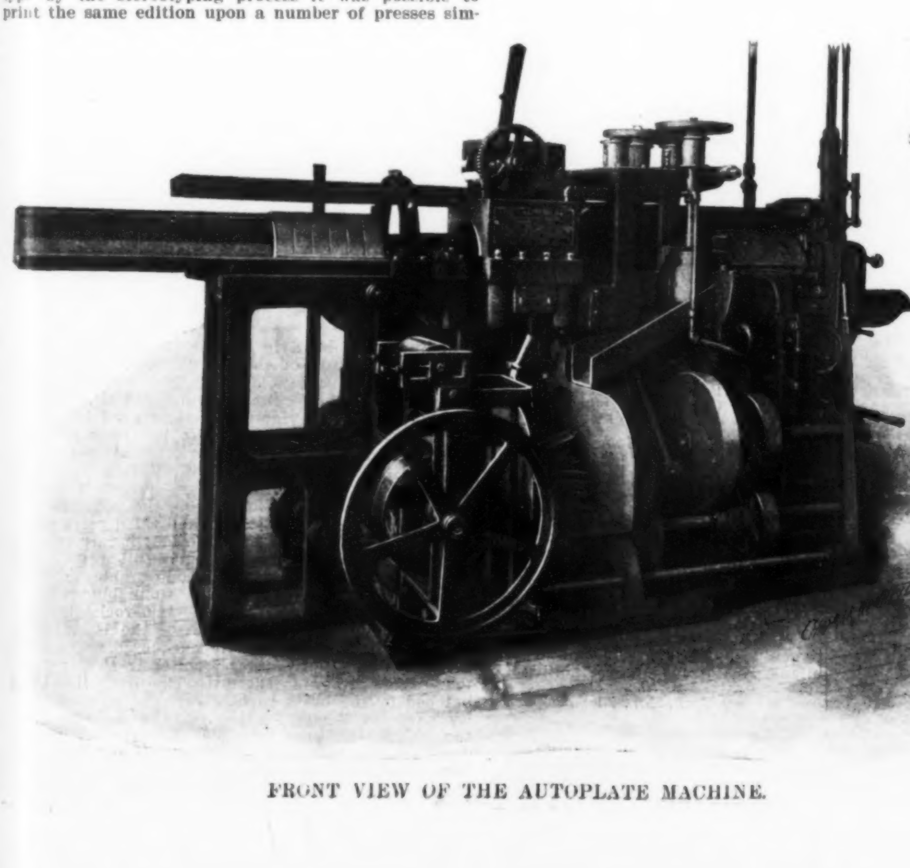
Briefly speaking, the "Autoplate" consists of a casting mechanism at one end of a machine and a series of finishing mechanisms at the other, which automatically co-operate to make the casts and finish them, and the speed at which it works is four plates a minute, cast, shaved out, finished and ready for the press. The operation of the machine is as follows:

A papier-mache matrix, which has been prepared in the usual way—by being squeezed upon the page of type and baked until it is hard—is secured in a matrix-holding device which has been slid out of the casting chamber, like a drawer, to receive it. Once secured the holding device with the matrix in position is slid back into the casting chamber, when upon manipulating a lever the machine begins automatically to make casts from the matrix and to deliver them successively to the various operations of finishing which succeed that of casting.

The casting chamber consists of a cylinder, as a core, which is disposed horizontally; beneath this cylinder is a semicircular shell, or cope, which is operated by mechanism to rise toward and surround the lower half of the cylinder with a space between equal to the thickness of the plate to be cast, and to remain in this position during the pumping-in of the molten metal, which is done at one stroke, and to drop away so soon as the resulting cast is cooled. In dropping away the matrix-holding device, which is secured to the shell, strips the matrix from the cast and frees the plate which adheres to the cylinder so that the cylinder may eject it, which it does by making a half revolution bringing the plate to its upper side, from which the plate is taken by automatic means

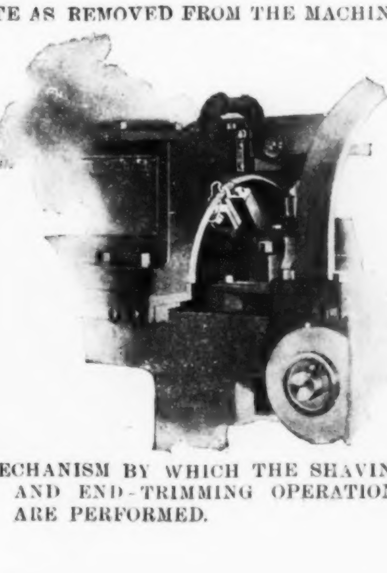


REAR VIEW OF THE AUTOPLATE MACHINE.



FRONT VIEW OF THE AUTOPLATE MACHINE.

FINISHED PLATE AS REMOVED FROM THE MACHINE.



MECHANISM BY WHICH THE SHAVING AND END-TRIMMING OPERATIONS ARE PERFORMED.

through the various finishing operations. The plate is cast with the convex side beneath, but after having been ejected from the casting chamber its convex side is uppermost. So soon as it reaches this position the semicircular shell beneath again rises into casting position, and carries with it the matrix which is automatically positioned for a second cast, which is made, freed of the matrix, and delivered as was the first cast.

During the second operation of casting, the first cast, which was left above the cylinder, is carried forward on its two straight edges between four saws which remove the spew at one side and a small riser at the other. The cast then goes into a semicircular machine which is called the shaving-dome, where it is clamped by its edges while a smooth-edged knife dresses out its under surface so that it will fit smoothly upon the cylinder of a printing press. At the same time two side knives reach over the ends of the cast and bevel and dress them close up to the edges of the type matter. These bevels provide the clamps of the press with the necessary gripping facilities so that the plate may be held securely upon the press even though rotated at the rate of two hundred turns a minute.

From the shaving-dome the plate is thrust out upon a long saddle where such additional finishing as may be necessary is done with power-driven hand-guided routing tools which are parts of the machine constructed for that purpose. It will be seen that by the various mechanisms described a semicircular printing plate has been cast, has been shaved out inside, has been trimmed close up to the type at its head and foot, has had its ends beveled and trimmed close up to the type at its sides, and has been ejected—all automatically—to receive its final touches at the end of the machine, whence it is taken to the pressroom. This work is done at the rate of four printing plates per minute, whereas under the old hand process it was not possible to make plates at over one per minute, and it was but rarely that such a high speed was attained.

To return to the casting feature of this machine: The metal caldron holds 12,000 pounds of type metal, which is composed of lead, tin, and antimony, and is heated to about 550 deg. temperature. In this caldron is a lift pump which at the proper moment thrusts into the casting chamber 40 pounds of molten metal. As soon as this charge of metal is delivered to the casting chamber it is cooled by a circulation of water through the casting cylinder and through the semicircular shell or cope. Thus it is possible to cool the casts with exceeding rapidity.

The shaving-dome also is water-jacketed, so that the plate receives an additional cooling in the course of the shaving operation. It has been found that plates cast by Mr. Wood's method have a finer printing surface and a much harder one than those cast by hand, and that they are without the surface pores or imperfections which are common in the old method.

The following are also interesting novel features which are embodied in this machine: When the machine is in use it is always in motion, while the casting mechanism is thrown into or out of operation as required. The object of this being to permit of a quick change from one page of the paper to another without an unnecessary loss of time which would occur if the machine as a whole had to be stopped during the change of matrices. As it is, after the requisite number of plates from one matrix has been cast, by the manipulation of a lever the casting mechanism is stopped while the matrix is changed, but the finishing runs on and completes and delivers the last plates of the page that is being changed.

The machine is so constructed that in case of anything falling into it instead of breaking it will come to a stop. This feature and a number of other similar features make the machine as absolutely certain and dependable in its operation as it is possible for a machine to become. The machine is also supplied with a number of ingenious safety devices which prevent any of the molten metal from going astray and injuring those who are handling it.

The first machine was built by Mr. Wood for The New York Herald, where it was so successful that three other machines were ordered for that paper, and within a year it is safe to say that all of the large papers throughout the United States will be equipped with "Autoplates," The New York World, The Chicago Tribune and many others having already ordered them.

It is strange that the closing year of the nineteenth century should have witnessed the last act of the mechanicalizing of the printing trade, and from this standpoint in time it is obvious that the three greatest inventions which the nineteenth century has contributed to the newspaper world are the rapid rotary printing press, which was invented by Hoe and his associates in 1860, the linotype composing machine, which was invented in 1888 by Mergenthaler, and the "Autoplate," which was invented by Mr. Wood and put to work in the last year of the century.

A COLLIERY ENGINE NINETY-TWO YEARS OLD.

The Illustrated Guide, published in connection with the Exposition at Glasgow, Scotland, says that there is at the Farme Colliery, Rutherglen, near Glasgow, situated about a quarter of a mile from Dalmarnock Bridge and within ten minutes' walk of Rutherglen Station, an "atmospheric" or "Newcomen" engine, which has been at work drawing coal since it was erected in 1809. The cylinder never was bored, is open at the top, and the piston is packed from time to time with hemp, which, with a little water at the top, keeps it sufficiently tight, and it gets an occasional scrape to keep it in order. It takes about 35 seconds to lift coal from the bottom of the pit to the top; a man works the handle which admits steam to raise the piston and alternately water to condense the steam under the piston, so that the weight of the atmosphere may press down the piston. With the exception of one or two spur wheels, which were broken by accident, no part of the engine has been renewed. It is the oldest engine at work in Scotland, and the only "atmospheric" engine now at work in Great Britain. The boiler used was not made for this engine, but for another one in the district about the same date. It is of the "haystack" type. The engine cylinder is 32½ inches in diameter and 66-inch stroke. It is run at about 27 revolutions per minute. An indicator card taken in June, 1901, shows a mean pressure of 7.35 pounds. About 27 horse power are developed by the engine.

THE BRITISH ASSOCIATION AT GLASGOW.[*]

THE EXPERIMENTAL STUDY OF VARIATION.

The study of variation may be said to consist (1) in noting and classifying the differences between parents and their offspring; and (2) in determining by observation and experiment the causes of these differences, especially why only some of them are transmitted to future generations. The facts of variation having been dealt with at considerable length in a recent work by Mr. Bateson, I shall discuss chiefly the causes of variation.

Though for untold ages parents have doubtless observed differences in the form and temperament of their children, and though breeders have long noted unlooked for traits in their flocks and herds, the systematic study of variation is of very recent date. This is not surprising, for while the belief in the immutability of species prevailed, there was no special incentive either to collect the facts or inquire into the causes of variation; and since the appearance in 1859 of the "Origin of Species" biologists have been mainly occupied in discussing the theory of natural selection. Now that discussions as to the nature and origin of species no longer occupy the chief attention of biologists, variability—the fountain and origin of progressive development—is likely to receive an ever increasing amount of notice. Strange as it may appear, naturalists at the end of the eighteenth century concerned themselves more with the causes of variation than their successors at the end of the nineteenth. Buffon, who discussed at some length nearly all the great problems that interest naturalists to-day, after considering variation arrived at the conclusion that it was due to the direct action of the environment, and even invented a theory (strangely like Darwin's theory of pangenesis) to explain how somatic were converted into germinal variations. Erasmus Darwin and Lamarck also had views as to the causes of variation. Erasmus Darwin believed variability resulted from the efforts of the individual, new structures being gradually evolved by the organisms constantly endeavoring to adapt themselves to their surroundings. Lamarck about the same time endeavored to prove that changes in the environment produced new needs, which in turn led to the formation of new organs and the modification of old ones, use being specially potent in perfecting the new, disuse in suppressing the old. Both Erasmus Darwin and Lamarck, without attempting, or apparently even seeing the need of, any such explanation as pangenesis offered, assumed that definite acquired modifications were transmitted to the offspring, and they both further assumed that variations occurred not in many but in a single definite direction; hence they had no need to postulate selection. The speculations of Erasmus Darwin and Lamarck having had little influence, it fell to Charles Darwin to construct new and more lasting foundations for the evolution theory.

Charles Darwin, clearly realizing that variation occurs in many different directions, arrived at the far-reaching conclusion that the best adapted varieties are selected by the environment, and thus have a chance of giving rise to new species. Though impressed with the paramount importance of selection, Charles Darwin realized that "its action absolutely depends on what we in our ignorance call spontaneous or accidental variation."[†] Darwin, however, concerned himself to the last more with selection than with variation, doubtless because he believed variability sinks to a quite subordinate position when compared with natural selection. As variations stand in very much the same relation to selection as bricks and other formed material stand to the builder, Darwin was perhaps justified in rating so high the importance of the principle with which his name will ever be intimately associated. Though Darwin considered variability of secondary importance, it may be noted that he did more than any other naturalist to collect the facts of variation, and he moreover considered at some length the causes of variation. He regarded with most favor the view that "variations of all kinds and degrees are directly or indirectly caused by the conditions of life to which each being or more especially its ancestors have been exposed."[‡] Of all the causes which induce variability, he believed excess of food was probably the most powerful.[§] In addition to variations which arise spontaneously in obedience to fixed and immutable laws, Darwin believed with Buffon that variations were produced by the direct action of environment, and with Lamarck by the use and disuse of parts; and he accounted for the inheritance of such variations by his theory of pangenesis. Darwin seems always to have regarded the direct action of the environment and use and disuse as, at the most, subsidiary causes of variation; but Mr. Herbert Spencer and his followers regard "use-inheritance" as an all-important factor in evolution, while Cope and his followers in America, by a mixture of "use-inheritance" (Konetogenesis) and Lamarck's neck-stretching theory (Archæsthetism), apparently see their way to account for the evolution of animals with but little help from natural selection.

Prof. Weismann and others, however, have recently given strong reasons for the belief that all variation is the result of changes in the germ-plasm ultimately due to external stimuli, the environment acting directly on unicellular, indirectly on multicellular organism. It is convenient to speak of biologists who believe with Mr. Herbert Spencer in the law of use and disuse (use-inheritance) as Neo-Lamarckians, and of those who with Weismann refuse to accept the doctrine of the transmission of definite acquired characters, and in the case of multicellular organisms the direct influence of the environment as a cause of variation, as Neo-Darwinians. In discussing variability I shall assume that all variations are transmitted by the germ-cells; that the primary cause of variation is always the effect of external influences, such as food, temperature, moisture, etc.; and that "the origin of a variation is equally independent of selection and amphimixis" (Weismann, "The Germ-Plasm," p. 431), amphimixis being simply the means by which effect is given to differences inherited, and to the differences acquired by the germ-cells during their growth and maturation.

Theoretically the offspring should be an equal blend of the parents and (because of the tendency to reversion) of their respective ancestors. In as far as the offspring depart either in an old or in a new direction from this ideal intermediate condition they may be said to have undergone variation. The more obvious variations consist of a difference in form, size and color, in the rate of growth, in the period at which maturity is reached, in the fertility, in the power to withstand disease and changes in the surroundings, of differences in temperament and instincts, and in the aptitude to learn. In the members of a human family there may be great dissimilarity, and the dissimilarity may be even greater in the members of a single brood or litter of domestic animals, especially if the parents belong to slightly different breeds.

Frequently some of the offspring closely resemble the immediate ancestors, while others suggest one or more of the remote ancestors, are nearly intermediate between the parents, or present quite new characters. Similarly seedlings from the same capsule often differ. Can we by way of accounting for these differences only with Darwin say variations are due to fixed and immutable laws, or at the most subscribe to the assertion of Weismann, that they are "due to the constant recurrence of slight inequalities of nutrition of the germ-plasm"? ("Germ-Plasm," p. 431.) Weismann accounts for ordinary variation by saying that the reduction of the germ-plasm during the maturation of the germ-cell is qualitative as well as quantitative, i. e., that the germ-plasm retained in the ovum to form the female pro-nucleus is different from the germ-plasm discharged in the second polar body. He accounts for discontinuous variation and "sports" by "the permanent action of uniform changes in nutrition" ("Germ-Plasm," p. 431). These uniform changes in nutrition by modifying in a constant direction susceptible groups of germ-units (determinants) after a time giving rise to new, it may be pronounced variation. Must we rest satisfied with these assumptions, or is it possible to account for some of the variability met with by, say, differences in the maturity of the parents or of the germ-cells, by the germ-cells having been influenced by interbreeding or intercrossing or by the soma in which they are lodged having been invigorated by a change of food, or habitat, or deteriorated by unfavorable surroundings or disease? In other words, are there valid reasons for believing that the germ-cells are extremely sensitive to changes in their immediate environment, i. e., to modifications of the body, or soma containing them, and that the characters of the offspring depend to a considerable extent on whether the germ-cells have recently undergone rejuvenescence?

Obviously, if the offspring, other things being equal, vary with the age of the parents, the ripeness of the germ-cells and with the bodily welfare, the qualitative division of the nucleus on which Weismann so much relies as an explanation of ordinary variation will prove inadequate.

IS AGE A CAUSE OF VARIATION?

During the course of my experiments on variation I endeavored to find an answer to the question, "Is Age a Cause of Variation?" During development and while nearly all the available nourishment is required for building up the organs and tissues of the body, the germ-cells remain in a state of quiescence. Sooner or later, however, they begin to mature, and eventually in most cases escape from the germ-glands. I find the first germ-cells ripened often prove infertile. When, e. g., pigeons from the same nest are isolated and allowed to breed as soon as mature, they seldom hatch out birds from the first pair of eggs, and though quite vigorous in appearance, they may only hatch a single bird from the second pair of eggs. The same result generally follows mating very young but quite unrelated pigeons; but when a young hen bird is mated with a vigorous, well-matured male, or a young male is mated with a vigorous, well-matured female, the eggs generally prove fertile from the first. The germ-cells are, as far as can be determined, structurally perfect from the outset; and that they only fail in vigor is practically proved by the fact that though the conjugation of germ-cells from two young birds leads to nothing, the conjugation of germ-cells from quite young birds with germ-cells from mature birds generally at once results in offspring.

The following experiments indicate how age may prove a cause of variation. Last autumn I received from Islay two young male blue-rock pigeons which, though bred in captivity, were believed to be as pure as the wild birds of the Islay caves. In February last one of the young blue-rocks, while still immature, was placed with an inbred white fantail, the other with an extremely vigorous well-matured black barb. In course of time a pure white bird was reared by the white fantail, and two dark birds by the black barb. Owing probably to the fantail being inbred and the blue-rock being still barely mature, the young white bird died soon after leaving the nest. No birds were hatched from the second and third pairs of eggs laid by the fantail, but from the fourth pair two birds were hatched which are now nearly full-grown. These young birds are of a darker shade of blue, and look larger and more vigorous than their blue-rock sire. As in the Indian variety of the blue-rock pigeon the croup is blue, and, as in some of the Eastern blue-rocks, the wings are slightly chequered. They, however, only essentially differ from their sire in having four extra feathers in the tail. The first pair of birds hatched by the black barb, when they reached maturity early in August, might have passed for young barbs with somewhat long beaks. Since the first pair were hatched in March the blue-rock and black barb have reared six other birds. One of the second brood closely resembles the first birds hatched; the other is

[*] Opening Address by Prof. J. Cossar Ewart, M.D., F.R.S., President of Section D.

[†] "Animals and Plants," vol. ii, p. 206.

[‡] Ibid., vol. ii, p. 240. Elsewhere he says we are "driven to the conclusion that in most cases the conditions of life play a subordinate part in causing any particular modification."

[§] Ibid., vol. ii. p. 282.

of a grayish color, with slightly mottled wings, a long beak, and a tail bar. The birds of the third nest are both of a grayish color, but have indistinct wing bars as well as a tail bar. Of the fourth pair of young, one is grayish, like the birds of the third nest, the other is of a dark blue color, with slightly chequered wings, and a head, beak and bars as in its blue-rock sire. The gradual change from black to dark blue in the blue-rock barb crosses is very remarkable. I can only account for the almost mathematical regularity of the change by supposing it has kept pace with a gradual increase in the vigor or prepotency in the young blue-rock. Eventually the offspring of the blue-rock mated to the black barb, like the offspring of its brother with the white fantail, may be of a slaty blue color, and otherwise resemble a wild blue-rock pigeon. Many breeders would explain the offspring taking more and more after the sire by the doctrine of Saturation—a doctrine that finds much favor among breeders—but as identical results were obtained when young females were mated with well-matured males the saturation explanation falls to the ground.

Like results were obtained by breeding young gray quarter-wild rabbits with an old white Angora buck; the first young were white, the subsequent young were white, gray, and bluish gray. From these results it follows that when old and young but slightly different members of a variety or species are marked a wonderfully perfect series of intermediate forms is likely to be produced. Among wild animals the young males rarely have a chance of breeding with the young females; hence among wild animals, owing to age being a cause of variation, a considerable amount of material is doubtless constantly provided for selection, thus affording a variety an additional chance of adapting itself to slight fluctuations in the environment.

In the results obtained by crossing mature, vigorous, and, in some cases, inbred males with barely mature females, an explanation may be found why in some families the same features have persisted almost unaltered for many generations; why in his features the squire of to-day sometimes exactly reproduces the lines of his ancestors, as seen in portraits and monumental brasses. It should, however, be borne in mind that highly prepotent forms are capable from the first of so completely controlling the development that they transmit their peculiar traits to all their offspring.

IS RIPENESS OF THE GERM CELLS A CAUSE OF VARIATION?

While difference in age may sometimes account for the earlier broods and litters resembling one of the parents, it fails to account for the very pronounced variation often found in a single brood or litter, and for much of the dissimilarity between members of the same human family. When a *single* fertilized germ-cell, as occasionally happens, gives rise to twins, they are always identical; hence it may be assumed the differences in members of the same family have their source in differences in the germ-cells from which they spring. If the offspring vary with the maturity of the soma, it may also vary with the maturity of the germ-cells, or at least with their condition at the moment of conjugation.

Some years ago Mr. H. M. Vernon, when hybridizing echinoderms, discovered that "the characteristics of the hybrid offspring depend directly on the relative degrees of maturity of the sexual products" (Proceedings Royal Society, vol. lxiii., May, 1898). Mr. Vernon found subsequently that over-ripe (stale) ova fertilized with fresh sperms gave very different results from fresh ova fertilized with over-ripe (stale) sperms, from which he inferred that over-ripeness (staleness) is a very potent cause of variation (ibid., vol. lxv., November, 1899).

I find that if a well-matured rabbit doe is prematurely (i. e., some time before ovulation is due) fertilized by a buck of a different strain, the young take after the sire; when the fertilization takes place at the usual time, some of the young resemble the buck, some the doe, while some present new characters or reproduce more or less accurately one or more of the ancestors. When, however, the mating is delayed for about thirty hours beyond the normal time, all the young, as a rule, resemble the doe. It may hence be inferred that in mammals, as in echinoderms, the characters of the offspring are related to the condition of the germ-cells at the moment of conjugation, the offspring resulting from the union of equally ripe germ-cells differing from the offspring developed from the conjugation of ripe and unripe germ-cells, and still more from the union of fresh and over-ripe germ-cells. This conclusion may be said to be in harmony with the view expressed by Darwin, that the causes which induce variability probably act "on the sex elements before impregnation has been effected" ("Animals and Plants," vol. ii., p. 259). The results already obtained, though far from answering the question why there is often great dissimilarity between members of the same family, may lead to further experiment, and especially to more complete records being kept by breeders. It is unnecessary to point out what a gain it would be were breeders able to regulate, even to a small extent, the characters of the offspring.

IS THE CONDITION OF THE SOMA A CAUSE OF VARIATION?

There is a considerable amount of evidence in support of the view that changes in any part of the body or soma which affect the general welfare influence the germ-cells. This is but what might be expected if the soma in the metazoa is to the germ-cells what the immediate surroundings are to the protozoa. The soma from the first forms a convenient nidus for the germ-cells, and when sufficiently old and sufficiently nourished it provides the stimuli by which the ripening (maturing) of the germ-cells is effected. If in the case of the protozoa variation is due to the direct action of the environment, it may be inferred that in the metazoa variations of the germ-cells result from the direct action of the soma, i. e., from the direct action on the germ-cells of their immediate environment. This, however, is quite a different thing from saying that definite somatic variations are incorporated in the germ-cells (converted into germinal variations) and transmitted to the offspring.

It may first be asked: Does disease in as far as it reduces the general vigor or interferes with the nutrition of the germ-cells act as a cause of variation? I recently received a number of blue-rock pigeons from India infected with a blood parasite (Halteridium) not unlike the organism now so generally associated with malaria. In some pigeons the parasites were very few in number, in others they were extremely numerous. The eggs of a pair of these Indian birds with numerous parasites in the blood proved infertile. Eggs from a hen with numerous parasites fertilized by a cock with a few parasites proved fertile, but the young died before ready to leave the nest. An old male Indian bird, however, with comparatively few parasites mated with a mature half-bred English turbit produced a single bird. The half-bred turbit has reddish wings and shoulders, but is otherwise white. The young bird by the Indian blue-rock is of a reddish color nearly all over, but in make not unlike the cross-bred turbit hen.

Some time before the second pair of eggs were laid the parasites had completely disappeared from the Indian bird, and he looked as if he had quite recovered from his long journey, as well as from the fever. In due time a pair of young were hatched from the second eggs, and as they approached maturity it became more and more evident that they would eventually present all the distinctive points of the wild-rock pigeon.* The striking difference between the first bird reared and the birds of the second nest might, however, be due not to the malaria parasites, but to the change of habitat.

Against this view, however, is the fact that another Indian bird infected to about the same extent as the mate of the half-bred red turbit counted for little when mated with a second half-bred turbit, while two Indian birds in which extremely few parasites were found at once produced blue-rock-like birds when bred —one with a fantail, the other with a tumbler.

Another possible explanation of the difference between the bird of the first and the birds of the second nest is that the germ-cells were for a time infected by the minute protozoan Halteridium in very much the same way as the germ-cells of ticks are infected by the parasite of Texas fever. But of this there is no evidence, for even in the half-grown birds hatched by the pure-bred malarious Indian rocks the most careful examination failed to detect any parasites in the blood. In all probability Halteridium can only be conveyed from one pigeon to another by Culex or some other gnat.

These results with pigeons suffering from malaria seem to indicate that the germ-cells are liable to be influenced by fevers and other forms of disease that for the time being diminish the vitality of the parents. Further experiments may show that the germ-cells are influenced in different ways by different diseases.

Sometimes the germ-cells suffer from the direct action of their immediate environment, from disturbance in or around the germ-glands. If, for example, inflammation by the ducts or other channels reaches the germ-glands, the vitality of the germ-cells may be considerably diminished; if serious or prolonged, the germ-cells may be as effectively sterilized as are the bacteria of milk by boiling.

In 1900 two mares produced foals to a bay Arab which had previously suffered from a somewhat serious illness involving the germ glands. These foals in no way suggest their sire. This year I have three foals by the same Arab after he had quite recovered; one promises to be the image of his sire, and the other two are decidedly Arab-like both in make and action.

While the germ-cells are liable to suffer when the soma is the subject of disease, there is no evidence that they are capable of being so influenced that they transmit definite or particular modifications (unless directly infected with bacteria or other minute organisms); that, e. g., the germ-cells of gouty subjects necessarily give rise to gouty offspring. Doubtless if the germ-cells, because of their unfavorable immediate surroundings, suffer in vigor or vitality, the offspring derived from them are likely to be less vigorous, and hence more likely than their immediate ancestors to suffer from gout and other diseases.

It would be an easy matter to give instances of the offspring varying with the condition or fitness of the parents; but it will suffice if, before discussing intercrossing, I refer to the influence of a change of habitat.

IS CHANGE OF HABITAT A CAUSE OF VARIATION?

It has long been recognized that a change of surroundings may profoundly influence the reproductive system, in some cases increasing the fertility, in others leading to complete sterility. Exotic plants, sterile it may be at first, often become extremely fertile, and when thoroughly established give rise to new varieties. In the case of mares obtained from Iceland and the south of England sometimes a year elapses before they breed. An Arab-Kattiawar pony which arrived during April from India proved during the first three months quite sterile, owing, I believe, to loss of vigor on the part of the germ-cells, their vitality being only about one-tenth that of a home-bred hackney pony. But the fertility is apparently greatly impaired by even comparatively slight changes of environment. Lions which breed freely in Dublin seem to be sterile in London, and I heard recently that when bulls are changed from one district to another in the north of Ireland, complete sterility is sometimes the result. The tendency of some exotic plants to "sport" after they become acclimatized is doubtless due to the fact that their new habitat is unusually favorable, their general vigor —so essential for new developments—is increased, and, probably because certain groups of germ units are constantly stimulated by the new food available, they give rise abruptly or gradually to new and it may be unexpected characters. No one doubts that the bodily vigor is liable to be impaired by fevers and other diseases, by changes in the habitat, unsuitable food, rapid and unseasonable changes of temperature, and the like; hence it will not be surprising if further investigations prove that changes in the soma, beneficial as well as injurious, are reflected in the germ-cells, and thus indirectly induce variation. Moreover, there are excellent reasons for believing that the germ-cells are influenced by seasonable changes, such as moulting in birds and changing the coat in mammals. In the case of pigeons, e. g., the young bred in early summer are, other things being equal, larger and more vigorous, and mature more rapidly, than birds hatched in the late summer or autumn. But however sensitive the germ-cells may be to the changes of their immediate environment, i. e., the soma or body in which they are lodged, there is no evidence whatever that (as Buffon asserted and Darwin thought possible) definite changes of the soma, due to the direct action of the environment, can be imprinted on the germ cells. By the direct action of the environment—food, temperature, moisture, etc.—the body in whole or in part may be dwarfed, increased, or otherwise modified; but such changes only influence the germ-cells in as far as they lead to modifications of the body, as a whole. They may expedite or delay maturity, after the length of the reproductive period, interfere with the nutrition of the germ-cells, or retard the development of the embryo, but they seem incapable of giving rise to definite structural or functional variations in the offspring.

(To be continued.)

* In these young birds the breast and some of the wing feathers are imperfect. Fanciers regard this condition of the feathers as evidence of constitutional weakness.

HOW OUGHT PHOSPHATIC SLAG TO BE EMPLOYED IN AGRICULTURE.*

THE slags proceeding from the process of dephosphoration furnish phosphoric acid in the state of calcium tetraphosphate, very soluble in water charged with carbonic acid or in organic acids.

Their employment is quite advantageous on account of the great assimilability of the phosphoric acid, and also because they can be purchased at a lower price than the superphosphates.

They yield to analysis 14 to 16 per cent, and they can be purchased at the rate of 5½ or 6 francs per 100 kilos, which makes the price of the unit 37 to 40 centimes. Its price in the superphosphates is about 48 centimes.

Many tests have been made in order to determine whether the slag has the same fertilizing value as the superphosphates. There would be no advantage in buying phosphoric acid at a cheaper rate if it were of inferior quality.

The following are the results of experiments conducted by Grandeau in the cultivation of oats.

The parcels of land received the same quantity of sodium nitrate.

Fertilizer.	Yield of the Oats in Quintals. Straw.	Grain.
Nitrate alone	15.00	3.20
Nitrate and superphosphate	14.71	9.50
Nitrate and Ardennes phosphate	33.71	15.00
Nitrate and slag	31.25	20.00

These figures are instructive. The value of phosphoric acid for cereals is quite evident.

The inferiority of the superphosphate indicates a land poor in lime and of acid quality, so that the acidity of the superphosphate, not being utilized by the lime in the soil, has added to its natural acidity.

The excess obtained with the Ardennes phosphate evidences this acidity of the soil. It may also be said that the phosphoric acid was not in a very assimilable form, since the sodium nitrate has yielded an exaggerated proportion of straw. The slag, also, by its percentage in lime, has benefited the acid soil, and by the assimilability of its phosphoric acid, has corrected the exuberance of the herbaceous vegetation and raised the yield of grain 10 hectoliters.

If the experiment had been made on calcareous soil, the superphosphate would have proved superior to the fossil phosphate and equal to the slag.

The slag is adapted to all lands where liming is necessary or advantageous, for in addition to being a fertilizer, it improves them otherwise.

It is furnished in trade in a pulverized form, of which the degree of fineness is not without influence on its efficacy, as has been shown by the experiments of Wagner at Darmstadt.

It is applied as much as possible before sowing, which allows of burying to a certain depth in the soil. It is known that deep burying is necessary for plants with long roots; the beet in particular.

The following table, relating to the work of Peterman, of the Agricultural Institute of Gembloux, needs no comment:

Cultivation of Sugar Beets.

Fertilizer.	Yield per Hectare. Kilos.	Saccharine Richness.
Without fertilizer	17.675	10.52
Fertilizer buried with the rake	22,500	10.62
Fertilizer buried with the hoe	32,674	11.02
Fertilizer buried with the spade	30,543	11.05

So it is necessary to advise in cultivation of this kind for all weeded plants to bury three-fourths of the fertilizer to a certain depth, and to allow one-fourth to remain on the surface for the first needs of the plant.

For the particular case of the sugar beet, which is being introduced very judiciously in our southern cultivation, I will cite the results of experiments made in 1898 by Messrs. Tetard on their farm at Gonesse.

These gentlemen ascertained that the highest yield was obtained by mingling the slag with the superphosphates, 600 kilos of slag and 200 kilos of superphosphates having produced 100 quintals more than 500 kilos of superphosphates alone.

The analysis of the roots showed that 300 kilos of the slag alone yielded 4,819 kilos of sugar to the hectare; 500 kilos of superphosphates yielded 5,803 kilos per hectare; 1,000 kilos of slag yielded 6,227 kilos of sugar; 600 kilos of slag and 500 kilos of superphosphates yielded 7,371 kilos per hectare.

For cereals, having generally superficial roots, the slag, if it has not been done sooner, can be spread *en couverture* (by mulching). The winter or spring

* From the French of F. Conston, agricultural engineer, in the Revel Agricole.

rains will then carry it to the slight depth necessary for the roots.

The operation of the spreading is of the highest importance with reference to the utilization by the plant of the nutritive matter introduced into the soil. The more plentiful and the more regular the dissemination, the greater will be the yield.

The slag, on account of its specific weight, is readily scattered, but in our region the northwest wind is often an obstacle to the application of the fertilizer at the right moment. The use of fertilizer distributers may therefore be advised, but it is better, I think, to mix the slag with fine earth, which may be scattered in a slight wind, still too rough for sowing the slag. This mixture causes a more regular spreading; the workmen cannot scatter large parcels at once. The employment of the distributers is also useful when there are large quantities of slag to scatter, to prevent corrosion of the hand of the workman.

The slag should be mixed with other fertilizers, but it is necessary to state that there should not be ammonium sulphate in the mixture, for ammonia would be immediately disengaged. The proportions to be employed depend on the richness of the soil and on the plant to be cultivated. It may be said that if the soil is lacking in phosphoric acid, no inconvenience will result from applying the slag profusely.

THE TANREC.

The Berlin Menagerie, according to the Illustrirte Zeitung, numbers among its collections of rare animals two specimens of the Madagascar tanrec, an insectivorous animal which has inherited from its ancestors certain characteristics that are not to be found in any of the species of hedgehog. One of these hereditary characteristics is the bristling coat of the animal, which marks the transition stage from hair to spine. True bristles or spines in the tanrec are found only on the occiput, on the neck, and on the sides of the body, where they are longest. The covering on the back of the animal consists of a bristle-like formation, while the abdomen and legs are covered by hair. The tanrec lives in the dense underbrush and ferns of its native island. As a skillful borer the tanrec forms passages and galleries in the earth, which may sometimes cover a considerable area. One of the peculiarities of the animal is its summer hibernation. The tanrec thus sleeps during the time in which it is difficult to obtain nourishment. So delicate is the flesh of the creature that it is rather keenly hunted by the natives of Madagascar.


THE MADAGASCAR TANREC.

ICELAND'S EARTHQUAKES.

No part of the world excepting Japan and a few other Asiatic islands is visited so frequently by earthquakes as Iceland. This great volcanic rock is shaken by about seventy-five severe earthquakes in a century. The most violent effects are often found in the uninhabited parts of the country which comprise most of the island. Of course, in these cases, there is not much destruction of life or property; this is the reason why comparatively little is heard of the earthquakes of Iceland.

Until the last great series of shocks occurred the earthquakes of Iceland were never studied by a man competent to collect accurate data and to describe them adequately. These earthquakes occurred five years ago in the western, or inhabited, part of the country and a great deal of damage resulted though the loss of life was very small. They continued through August and September, 1896. Later that fall Dr. Theodore Thoroddsen, who has made himself famous as the scientific explorer of Iceland, collected by correspondence much information from persons who lived in the disturbed area. In the summer of 1897 he traveled all through the region affected in order to study all phases of the catastrophe and to collect evidence from many eye-witnesses. He wrote an exhaustive report which was published in the Icelandic language in 1899, making a book of 200 pages. A condensed account of these earthquakes has just been published by Dr. Thoroddsen in German, and the few facts here given are taken from this long report.

While the earthquakes were felt throughout the entire southern lowland and all of the western fourth of the island, the most severe disturbances occurred in a triangular area in the southwest part not far from the sea and covering a district about 660 square miles in extent. Outside of this area and extending further inland strong shocks were felt over a region embracing about 1,500 square miles. Weaker effects were noted in a far larger area, outside these main regions of disturbance and including all the western part of the island; so that the total land area affected was about 21,000 square miles. As it is probable that an equally large area of the sea floor was disturbed it is supposed that the movements extended with greater or less intensity through the rocks covering an area of about 40,000 square miles or more than twice the area of New York State. The land surface affected was a little larger than this State. Reykjavik, the capital and chief town, was in the region of least disturbance, and practically no damage was done there.

If these earthquakes had occurred in any very populous land with high houses and large cities the destruction of life would have been very great. But in Iceland the danger is lessened by the peculiar type of buildings characteristic of the country. The village consists of small and low houses, the inner walls made of wood while the outer walls and roof are of warm grass thatch, a great protection against the winter cold. Stone houses are built in considerable numbers in the larger towns, but they are very dangerous for they are likely to become heaps of ruins immediately when assaulted by such terrific shocks as those of 1896. Wooden houses usually hold together until their occupants have time to get out of them. This is the reason why the loss of life is very small though a great number of buildings were destroyed or badly damaged.

Out of a total of 4,430 dwelling houses and 5,739 stables in the regions most severely shaken, 17 per cent were wholly destroyed and most of the remainder were severely damaged. The calamity was indeed a terrible one to the poor farmers, herders and fishermen, who comprise nearly all the population of Iceland; but fortunately their heavy material losses were their severest affliction. While many received slight wounds, few were badly injured and only four were killed outright. Nearly all the cattle and sheep were in the meadows, and so only nine cows and twenty sheep were killed. If the earthquake had occurred in winter when the animals were in the stables thousands of them would have perished.

The strongest and most destructive shocks were five in number beginning on August 26, the second on August 27, the third on September 5, the fourth on September 6 and the fifth on September 11. There were also a large number of shocks of less intensity and the movements continued with lessening strength till the end of September, 1897, or more than a year after they began. During the most violent periods the surface of the earth was in continual motion like the waves of the sea, so that neither men nor animals could stand on their feet but were thrown to and fro. These earth waves were plainly visible moving over the alluvial lowlands, but there was no trace of them among the mountains behind them.

Great landslides, however, occurred among the mountains. Skardsfjall, an isolated eminence rising about 700 feet above the plain, had the appearance of shaking itself like a poodle that has just come out of the water; many cracks appeared on its surface, and the thick blanket of earth that had covered its slopes slipped to the foot of the mountain where it lay in great heaps. Near Kroku, a great mass of earth several acres in extent and from six to nine feet in thickness was loosened from the underlying rock and slipped and rolled downward, though the slope was only one to two degrees. In another place a basalt rock, eight feet high and forty feet in circumference, was thrown some distance from its original position. Before each shock noises long drawn out and most alarming were heard in the interior of the earth.

A great many wide crevasses were found. Some of them, six to nine miles in length, filled with water and looked like long, thread-like lakes, some of them also had an important influence upon the surface water, completely draining small lakes and swamps which they happened to cross.

The earthquakes had a remarkable influence upon many mineral springs and geysers. New ones came to light and others were apparently blotted out of existence. On the night of September 5-6 a new geyser, amid the most deafening noise, suddenly made itself manifest by an outburst of water, steam and stones that were shot 600 feet into the air. Its force rapidly subsided and in a few days the ebullition was only twelve to sixteen feet above the surface. A year later the basin it had formed had a length of fifty-five feet and a breadth of thirty feet and was filled with clear hot water. The renowned Strokkur geyser, which came into action at the time of the great earthquake in 1789, suddenly suspended all activity in the earthquake period of 1896, and a year later its basin was full of tepid water. Still later, however, it regained its power and at last accounts had frequent periods of violent outbursts, throwing water to a great height. The hot spring at Biskupstungur, which merely boiled before the earthquake, now throws its water from twenty-five to thirty-five feet in the air. Many cold springs and wells underwent great changes, old ones disappearing and new ones being formed.

As is usual in Iceland the earthquakes began in the east and the movement was toward the west. The volcanoes Hecla, Kalta and Eyjafjallajökull were completely passive during and after the earthquake periods.

The southern lowland where these disturbances originated is an area of subsidence. Steep mountain slopes form the boundary between the highland and the low plain. Dr. Thoroddsen says the probability is that this boundary line extends deep into the earth as a line of breakage in the rocks. The earthquakes in the plain, probably caused by breakages and slippings among the deep-seated rocks under the plain, do not send their earth waves among the mountains of the interior, for the spreading of these waves to the highlands is interpreted by deep-lying crevasses and dislocations in the rocks. But the tremendous jar caused by these subterranean movements is felt far and wide, so that the effects of a severe earthquake extend over a large part of the island.—New York Sun.

NEW RESEARCHES ON THE ALLOYS OF GOLD, SILVER, AND OTHER MATTER FOUND IN THE EGYPTIAN TOMBS.*

By M. Berthelot.

In pursuing my researches on the metals of antiquity, I have been led to make a special examination of the samples of pure or alloyed gold proceeding from Egyptian tombs, and particularly of fine leaves used in the gilding of mummies and other objects. I have endeavored to see if it were possible to establish some probable relations between the chemical composition of these leaves and the date and the processes of their manufacture, in the cases where this date is established by the archæologists, so as to be able in other cases to ascend from the composition revealed by chemical analysis, either to the unknown date of manufacture or to the mineralogical origin of the samples. To arrive at conclusions of value, the determinations must be repeated sufficiently.

I have already published some results of this kind in my studies on the Dahchour excavations and on the samples furnished by our confrère, M. Maspero, director of Egyptian Antiquities. He has had the kindness to send me various new samples, and I will give the results of my examination.

A. I. Small fragments of gold, from the tomb of King Horus of Dahchour, XIIIth dynasty.—This sample weighs 0.0082 gramme. It is a beaten metallic leaf (about a thousandth of a millimeter thick). The tint of the two surfaces is notably different, one of them being of a pure golden yellow, the other reddish and quite dark in places. This last tint is distributed unequally. It does not appear attributable to the metal itself, but to an extremely thin coating of organic material, proceeding without doubt from contact with the mummy. The weight is not appreciable on so small a sample. The material burns when the gold is subjected to a red heat, and the metal retakes its normal color.

The analysis has furnished in 100 parts—Gold, 92.7; silver, 4.6; other matters, 2.4 per cent.

B. Two little packets of metallic leaves designated as gold, silver, or electrum, coming from a tomb of the XIth or XIIth dynasty (XIIth probably), discovered at Bercheh and belonging to a certain Tahoutinakhout.—I have divided these leaves according to their appearance into four groups for analysis.

II. Silver from packet No. 1.—Lamella, 0.002 mm. thick, on the average. Variable thickness, from 0.001 mm. to 0.0015 mm. and 0.0025 mm. Gold, 74.53; silver, 14.94; patina and other matter, 10.54.

III. Yellow gold of packet No. 1.—Gold, 80.1; silver, 20.3 = 100.4 per cent.

IV. Red gold of packet No. 1.—Lamella of about 0.001 thickness in the thinnest parts. Gold, 78.7; silver, 20.9 = 99.6 per cent.

V. Yellow gold of packet No. 2.—Lamella about 0.001 mm. in thickness. Gold, 77.3; silver, 22.2 = 99.5 per cent.

VI. Deeper red gold of packet No. 2.—The gold is tarnished on one side by an organic matter, like that of sample I., which gives it the appearance of being plated. This matter is destroyed when the gold leaf is heated to the red. Thickness about 0.001 mm. in the thinnest parts. Gold, 78.2; silver, 21.1 = 99.3 per cent.

It will be remarked that the gold leaves have a thickness of about one to two thousandths of a millimeter, but without regularity. The samples III., IV., V., VI., have nearly the same composition, consisting of an artificial alloy or of a native mineral, which contains four parts of gold and one part of silver. The difference in tint, which made the distinct existence of gold and of electrum thought of, is attributable to a thin coating produced by the contact or by the emanations of the mummy.

Sample II. is composed of silver mixed with one-fifth of gold, an alloy, or rather a native ore.

Like the Dahchour treasure, none of these samples

* Paper presented to the Académie des Sciences.

is of pure gold; the ratio of gold to silver is five to one; the gold leaves of the VIth and of the XIIth dynasties contain only 3.2 to 4.5 hundredths of silver, a ratio similar to those of sample I., proceeding from the Horus tomb. This confirms the preceding remarks on the composition of Egyptian gold.

C. Other objects.—I will give the results observed on some other objects coming from the same tomb.

VII. Solid material, reputed perfume.—This is a fragile resin, of a brownish yellow, compact, with conchoidal fracture. Heated, it behaves like colophony, having a similar odor.

VIII. Two round whitish bowls, having the appearance of a petrified material, afterward agglomerated by desiccation. The tomb contained about thirty of them. Diameter, 22 mm.

These bowls were regarded by the persons who found them as perfume. I have ascertained that they do not contain organic matter. They are in reality made up of fragments of pulverized glass, not porphyrized, rich in silica, and associated with a little calcium carbonate, which must have served as cement. The density of the matter is about 2.60. It is difficult to comprehend the motives which have led to the placing of such articles in a tomb.

IX. M. Maspero has added to his parcel a little red metallic lamella, about 60 mm. long, 6 to 7 mm. wide, according to the points, and 0.66 mm. thick and covered in places with verdigris. I have found in 100 parts of it: Copper, 87.7; tin, trace; oxidized patina, about 12.3. I do not know to what object it previously belonged.

X. In examining the gold leaves, alloyed with one-fourth of silver, included in *B*, I found three little rings, perfectly alike and regular, which have occupied my attention. One of them weighed 13.9 mgr. It constituted a regular tore. Its outer diameter was equal to 3.05 mm.; the diameter of the tore was 0.75 mm., and consequently the diameter of the interior circumference, 1.55 mm.

This ring was made of devitrified glass, without tin or any other metal in its interior, but covered with a thin greenish patina, containing a trace of copper.

The existence of such objects raised new questions. In fact, these little rings must have hung on some object of art or of attire, such as a necklace of glass beads, because they have not been connected by soldering, but strung on a linen or metal thread. Their manufacture must have presented some difficulty, because of the thinness of the rings (0.75 mm.) compared with their diameter (3.05 mm.).

I will add to the preceding analysis that of a sample of Chaldean metal sent by M. Henzey. It is from the statuette of King Rim-Sin, of date about 2200 before our era. The filings detached contain: Copper, 92.9; sand, 0.2; oxidized potash, 8.9 (without other metal). It is almost pure copper, like the most ancient statuettes of Gondeah and of the palace of the King Our-Nina.

THE STEAM TURBINE.

The problem of thermodynamic energy conversion, so far as the reciprocating steam engine is concerned, is to-day not much nearer its solution than it was more than a century ago. Ideal in its complex construction and revolutionary in its applications and achievements, the steam engine, originating with Newcomen and perfected by Watt, is, however, very far from perfect as a heat engine, and there is little prospect that future improvements will bring this type of heat motor much closer to the ideal. This assumption is to some degree borne out by the fact that the improvements ever since the days of James Watt have only been mechanical, and even though these improvements naturally have increased its efficiency, the steam engine of to-day in its ingenious and complex perfection, thermodynamically presents little improvement over that of Watt.

The conversion of heat energy by means of the steam engine is accomplished by allowing steam to expand behind the piston, not utilizing its kinetic energy, but subjecting it to a resistance corresponding with its pressure. The ideal efficiency of this process, and in fact the solution of the problem of thermodynamic conversion, is expressed by the Carnot cycle.

This means that for the highest efficiency obtainable the steam should be expanded from maximum to minimum pressure and temperature, and furthermore this expansion should be adiabatic, which, as is well known in practical operation with the steam engine, is not and never can be accomplished. The reason for this, now so well known, need not here be mentioned.

When the science of steam engineering was thoroughly understood and the defects of and the improbability of further than mechanically improving the steam engine were realized, engineers and inventors, with more or less success, set about devising means for mechanical utilization of heat energy by methods promising a closer approach to the ideal than is possible with the reciprocating steam engine.

The activity along this line of research has been most marked in the past century, and among the devices having any pretense to rivalry with the reciprocating engine has been the rotary steam engine. This type of engine, successful in obviating the defects due to reciprocating motion, has, however, in other respects proven far inferior to the type it has sought to replace; it is especially wasteful of steam, and cannot, therefore, be seriously considered.

The steam turbine, as proposed by De Laval, has been brought out in a state of great perfection and practical application.

The steam turbine in principle is not new, being the first heat motor recorded in the history of steam engineering, as far back as 120 B. C., when Hero of Alexandria, then the center of the civilized world, describes an apparatus for utilizing heat energy. This apparatus, a reaction turbine, consisted of a spherical vessel mounted upon trunnions through which steam was admitted, to finally issue from openings tangential to the sphere. Many centuries later, in 1629, the Italian, Giovanni Branca, brought out the impact turbine, employing a jet of steam to impinge upon the vanes or blades of a wheel. This latter, familiar to us in the hydraulic motors of the Pelton type, exhibits in general principle the characteristic features embodied in the present-day De Laval steam turbine.

Thus we see as early as 1629 the introduction of the reaction and impact turbine, although of imperfect form and not capable of practical application, and all attempts at perfection along these lines have, until a comparatively short time ago, proven unsuccessful; this was probably owing, however, to the interest aroused in the success of Newcomen in 1705, and later by Watt and his followers, in perfecting the reciprocating engine.

The steam turbine is, in the form produced by De Laval, characterized by the great simplicity of its construction and the directness of its energy conversion, producing adiabatic and complete expansion, ideal conditions which can never be attained with the steam engine. That the steam turbine, which now more than rivals the steam engine, should have been known at such an early date and yet should have been so long delayed in its perfection in a practical form, may seem astonishing. This is, however, not remarkable, for even if the high efficiency of the steam turbine had been known to Hero, Branca, and others of early times, a practical steam turbine could not well have been produced for want of materials and tools of such refinement and quality as we to-day know are as essential to the construction of a successful steam turbine as are the principles involved. The steam engine, less exacting in this respect, has been the natural forerunner, producing the favorable conditions that have enabled us to weld another link to the chain of evolution in heat engines.

In 1883 De Laval made the first successful steam turbine, using it in direct connection with the shaft of the well-known cream separator manufactured in this country by the De Laval Separator Company. This, his first steam turbine, a reaction wheel, was, however, soon replaced by one of the Branca type, and of the results attained Prof. Thurston says: "The result was an astonishing efficiency in many cases of good design; and the Branca form, particularly, ex-

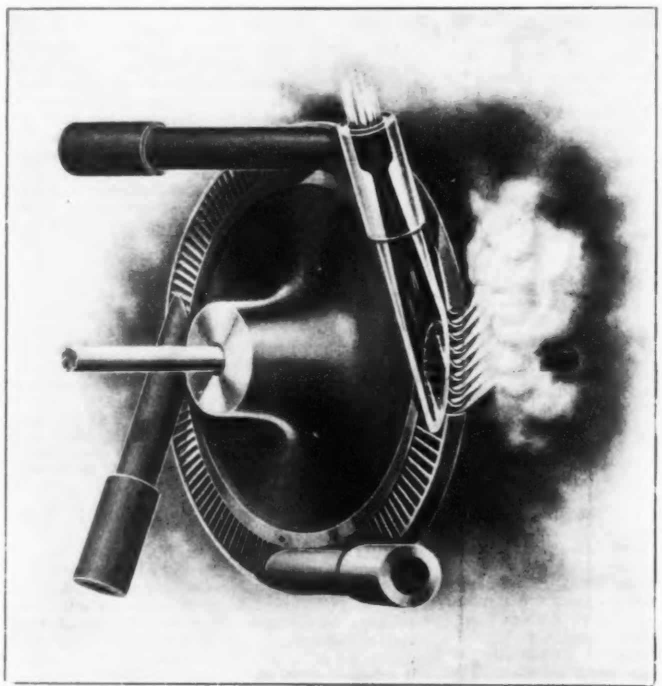


Fig. 1.—THE DE LAVAL TURBINE WHEEL AND NOZZLES.

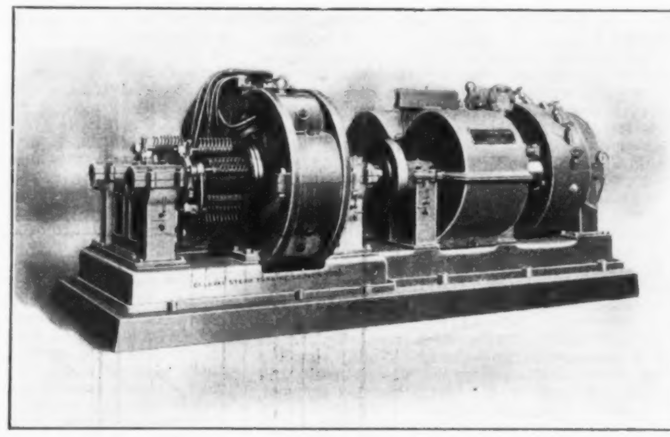


Fig. 3.—DE LAVAL STEAM TURBINE DYNAMO 300 H. P.

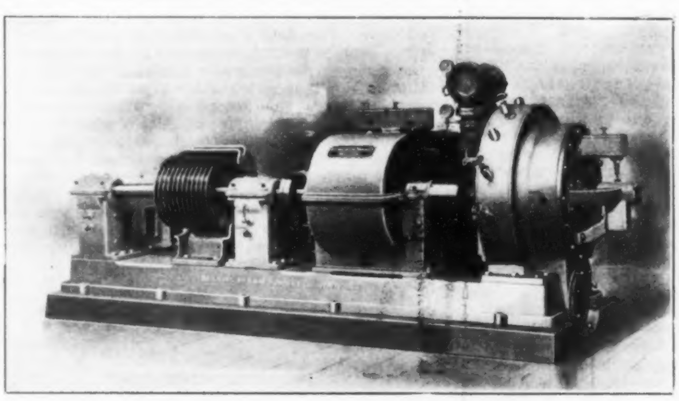


Fig. 2.—DE LAVAL STEAM TURBINE, 300 H. P.

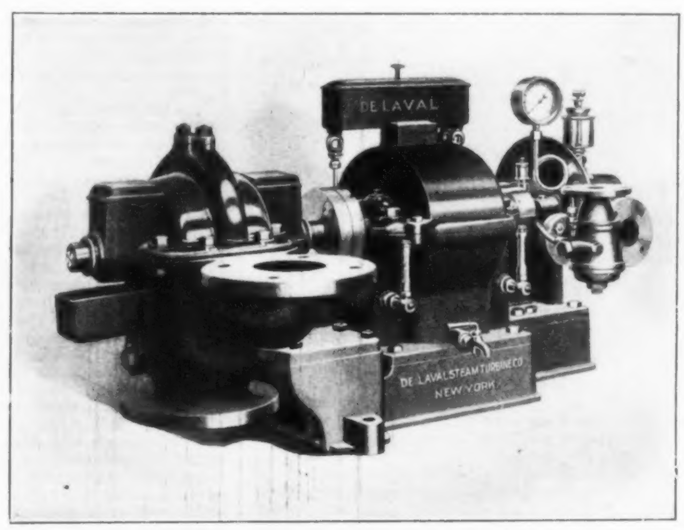


Fig. 4.—15 H. P. STEAM TURBINE PUMP.

hibited such satisfactory qualities as constructed by De Laval for this use as to make it a permanent and standard addition to our list of prime movers."

However, satisfactory as these results were, the steam turbine was yet very limited in its application and comparatively wasteful of steam, and to successfully compete with the reciprocating steam engine, it was necessary to introduce means for the complete expansion of the steam. Should the true Branca type be retained, the constructive difficulties arising out of the enormously high speed necessary would have to be overcome. This De Laval accomplished in a remarkable way. By use of the diverging nozzle, which he patented, he secured a complete and adiabatic expansion of the steam and the conversion of its entire static energy into kinetic, and to overcome the impossibility of producing a wheel accurately enough balanced to revolve about its center of gravity at a velocity sometimes as high as 1,350 feet per second, without causing a side pressure destructive to plain bearings and a rigid shaft, he used a flexible shaft.

The De Laval nozzle, the simplest means imaginable for its purpose, and the flexible shaft, daring and ingenious in its application, may well be regarded as among the most remarkable inventions in steam engineering. They have placed the steam turbine in the foremost rank among heat motors. With these improvements the De Laval turbine has steadily progressed, thousands of machines in sizes from 3 horse power to 300 horse power having been built.

A characteristic feature of this turbine is that none of its running parts are subject to the full pressure of the steam, as the steam is fully expanded in the nozzles before it reaches the turbine wheel. This feature is of great value in the direction of using high pressures with resultant increase in economy of fuel. The restriction as to the steam pressure that can be used is found only with the boiler, and as far as the steam turbine itself is concerned, it has been operated **successfully with a pressure as high as 3,000 pounds per square inch.**

Further and considerable increase in economy can be attained by using superheated steam, this steam turbine having no rubbing parts requiring lubrication, or packing glands in contact with the superheated steam, and, as in the case of high pressures, even here the limit exists alone with the boilers.

The general construction of the De Laval steam turbine will be clearly understood from Fig. 1. It presents no extraordinary departure from every-day engineering practice. However, the workmanship and material used, owing to the high speed employed, must be of the very highest quality.

The turbine wheel is mounted upon the slender flexible shaft, and in such position relative to the wheel case as to revolve entirely free, liberal space being allowed on each side. The wheel case and the wheel-case cover are so shaped as to form "safety bearings" around the hub of the wheel for the purpose of catching and checking its speed in case of an accident to the shaft.

The steam, after passing through the governor valve enters the steam chamber, where it is distributed to the various nozzles. These, according to the size of machine, range in number from 1 to 12. They are generally fitted with shutting-off valves, by which one or more nozzles can be cut out when the turbine is not loaded to its full capacity. This allows steam of boiler pressure to be almost always used, and adds to the economy on light loads.

After passing through the nozzles, the steam is completely expanded, and in blowing through the buckets, as shown in Fig. 1, its kinetic energy is transferred to the turbine wheel. After performing its work the steam passes into the chamber and out through the exhaust opening.

The velocity of the turbine wheel and shaft, in most cases too great for practical utilization, is considerably reduced by means of the spiral gear usually made 10 to 1. The gear is mounted and inclosed in the gear case. The pinion made solid with the flexible shaft and engaging the gear wheel. This later is forced upon the shaft, which with coupling connects to the dynamo or is extended for pulley. The governor is held with a taper-shank in the end of the shaft, and operates the governor valve by means of the bell-crank.

THE NAVAL WAR GAME.

By F. T. JANE.

FOR the last twelve months or so experiments have been conducted in England, France, Russia, the United States, and Japan, with a view to evolving a new firing system for the Naval War Game, that, while not necessarily displacing the existing system for small actions, shall yet afford something infinitely quicker than the old target method. The requirements were as follows:

a. Realism, that is to say, accuracy in fire, corresponding as nearly as possible to actual conditions.

b. Full differentiation between ships.

c. Speed in firing and scoring, so that the period of time representing one minute shall in no case exceed two minutes with players at all practised in the game.

d. Simplicity, so that tactics shall receive the maximum of importance.

e. Full allowance for position, speed, and bearing of guns, with, so far as possible, automatic adjustment for the targets of varying size offered by different types of warships, automatic and correct ratio between ships and forts, ships and destroyers, and all kindred cases.

f. Other things being equal, preference will be given to the method that puts the greatest individual responsibility upon the captains of ships.

g. Automatic adjustment to any other conditions not specified herewith, but which might occur in the fullest possible simulation of real warfare.

On this clause (*g*), which is, after all, merely a variation on clause *a*, several of the most promising systems came to grief.

Our readers must by now be fully cognizant of the original target system. By this each gun of or over 6 inches is struck for by an instrument known as a "striker," the size of the target varying with the range. An optional rule artificially increases the range if speed is high enough to alter rapidly bearings. In a general way, and for teaching guns and armor, this system has shown itself the best, and still so remains; but it has the defect of great slowness unless all the players are thoroughly well practised at the game. In practice it has worked out that few players get far beyond the learner stage. A highly-qualified umpire is also an absolute necessity; and, so far, there are only three such in existence in the world. Not only is it necessary to have all the rules and the innumerable addenda off by heart, but great quickness of perception and an ability to apply uniform judgment on widely different cases at sight are absolutely essential. Every possible contingency being provided for in the rules, the slightest divergence on some special case may completely upset other cases.

All this has struck many people as likely to defeat the end sought, and so created a demand for something less of a special science and with more generalization.

The first and most elementary idea that suggests itself to nearly everyone is a system of points. That, however, is already in existence on page 25 of the 1898 Book of Rules. It is a quite unsatisfactory method, because it reduces everything to simple mathematics, and requires only the intelligence necessary for skill at the game of draughts. It is, in fine, nothing but an exercise in mental arithmetic, thought and initiative being replaced by that. It is worthy of note, however, that this is the system favored by the British Admiralty, which, a few months since, served out to all sea-going ships a game consisting almost solely of the rules as to moving on page 8 of the 1898 Book of Rules, and a modification of the first clause on page 25 of the same issue. The arithmetical exercises may help naval officers to qualify for ability in keeping mess accounts, but the maximum of utility is bounded by that. As an exercise in war training, or in causing officers to think out war problems, it is practically useless. That such a system should have been adopted is the more curious in that all officers doing gunnery courses are now set to pursue their studies on the theory of areas of armored and unarmored parts of ships, which is the very keynote and distinctive feature of the Jane Naval War Game.

In pursuance of a solution of the best shooting method to fit requirements *a* to *g* above, no less than seventeen systems were evolved, each with many good points, but none of which answered all requirements in practice. To enter into a detailed account of all these systems would be tedious; it suffices to mention that dice and mathematics were the leading features, and that none accorded with the time requirement, nor were the automatic conditions in clauses *e* and *g* properly met. Out of the chaos, however, a system has been evolved that has so far stood every test satisfactorily, and which is now adopted as the official scale for all actions in which more than three or four ships are engaged on either side. The line followed is one of broad generalization, particularization being left with the umpire. Its main features are as follows:

Axioms.—1. In the battle of the immediate future at least 90 per cent of the projectiles will be high-explosive or common shell. Hence penetration of armor is quite a minor detail.

2. Victory will depend primarily upon the dispositions of the admiral before the battle, and upon the intelligence with which his subordinates grasp the general plan and exhibit initiative when the need occurs.

3. The percentage of hits to be obtained upon an enemy will depend as much or more upon the combined speed—and changing bearings—than on the actual distance.

4. Most ideas of modern warfare are based on "moral effect." Dice are, therefore, absolutely unsuitable, and mathematics must be strictly limited. Long experience indicates that the "striker" system gives an equivalent to moral effect; therefore, the "striker" must be used.

These ends have been obtained by the following revolutionary methods. All guns are commuted to 6-inch quick-firing; those of 8-inch, etc., quick-firing, being reckoned as 1½; those of 9.2, 12-inch, etc., varying from 1½ to 2½, according to the type of gun and mounting. Each ship, so long as she has a single gun left, is allowed one stroke per move, the spot hit being taken as the center of the area of damage, guns in it being affected whether protected by armor or not. As an example we may take the "Majestic." Her fire—excluding small pieces—commutes to 14, and this, upon the percentage of hits, is allowed for as seven sections destroyed at 2,000 yards or under if the ship fired at is stationary or nearly so. At 7,000 or 8,000 yards, however, only 1-20 of that damage is allowed; at 6,000—5,000 yards, 1-10 to 1-6; at 4,000 yards, ¼; at 3,000 yards, ½—i. e., 3½ sections.

For long ranges, i. e., 4,000 yards or over, the medium target—the old "3,000 yards" one—is used should bearings be absolutely unchanging, but if there is any change, then the "4,000-yard target." Every combined change of 15-knot speed makes the range reckoned as 1,000 yards greater than it actually is. For nearer ranges, inside 4,000 yards, the biggest target is used for a stationary ship, or one when bearings do not alter. When they alter only a little the medium —3,000 yards—target is employed. If they alter from 15 to 30 knots per move—as, for instance, two fleets passing each other at 12 knots—then the smallest target is employed. Beyond that speed the range is reckoned 1,000 yards greater for each 15 knots difference, and the damage correspondingly reduced. Boldly conventional as this system may seem, it embodies the strongest facts of actuality, and impresses—indirectly possibly—on players how important an item is the speed of the enemy.

For firing at destroyers mathematics are now employed—guns scoring from 8 to 1, according to the destroyer's speed. Range, so long as it is within the prescribed distance, is not counted, neither is position. Safety lies in speed, and defense lies in tactics to neutralize that speed. The new rule is simple as can be, but gets all the salient features and "things that matter."

Torpedoes have had to be readjusted. The assumption now is that a stationary ship can be hit at any range, and though nearness counts, speed and position count as much or more.

The automatic allowance for forts is as follows: Each fort gun is given the destructive power of two ship guns, or, if it is more than 500 feet above sea level, of three ship guns. Otherwise the range rules are the same.—The Engineer.

CONTEMPORARY ELECTRICAL SCIENCE.*

METALLIC CONDUCTION.—E. Riecke attempts the question: Is metallic conduction attended by a transport of metallic ions? Such a transport of ions was suggested by the observed diffusion of metallic ions through solid metals, and was consistent with the author's electro-thermal theory. The apparatus used by the author consisted of three equal cylinders, two of them being of copper and the third of aluminium. They were firmly pressed together, with the aluminium cylinder in the center, and provided with copper leads. The apparatus was kept in the closed circuit of a battery of accumulators for a whole year, during which time it was traversed by about 958 ampere-hours. In an electrolytic cell this would have meant the deposition of 1.14 kg. of copper. But on weighing the cylinders at the end of the year it was found that, within experimental errors, their weight had not altered. The author, therefore, answers the above question in the negative, and concludes that in metallic conduction no electric charges are conveyed by positive metallic ions.—E. Riecke, Physikal. Zeitschr., August 3, 1901.

EFFECT OF GRAVITY AND PRESSURE ON E. M. F.—When an electric current is passed through an electrolytic cell the anode is dissolved while the cathode is plated. If the cell is made in the form of a tube, with the electrodes in the ends, the law of the conservation of energy would require a greater consumption of energy when the current passes up through the tube than when the tube is horizontal or when the current passes down. This greater consumption of energy will express itself as a difference in the E. M. F. required for a given rate of deposit, and this difference may be regarded as a counter E. M. F. and detected as such. Some experiments in this direction have recently been made by Rolla R. Ramsey. Starting with the tube in horizontal position, the tube was turned to a vertical position and reversed repeatedly in unison with the galvanometer needle until a maximum deflection was obtained. Zinc or cadmium amalgams were used as electrodes, and the sulphates, either in solution or in paste, as electrolytes. The most consistent results were obtained with cadmium. The additional E. M. F. per centimeter height of a 10 per cent solution was found to be 4.78×10^{-8} volts, with a migration ratio of 0.02. The authoress also measured the effect of pressure, and found that the E. M. F. increased in a linear manner with the pressure up to 300 atmospheres, and to a larger extent in a Clark cell than in a cadmium cell.—R. R. Ramsey, Phys. Review, July, 1901.

THE BRAUN TUBE AS AN ELECTROMETER.—Braun's cathode-ray tube has been used with much success for studying the period of alternating currents. W. I. Milham has found it useful for measuring electrostatic fields, but in a somewhat indirect manner, for when the tube is placed between the electrodes, there is no deflection of the cathode beam; when, however, the field is suddenly commutated, the fluorescent spot jumps aside, and then returns to its normal position, quickly at first, and then more slowly. On repeating the commutation the throw is in the opposite direction, and the return is as before. The explanation is obvious. The field traverses the tube, but the cathode rays within the tube render the gas conducting, and the charges on the walls are thus neutralized. That this is the true explanation may be proved by interrupting the cathode rays during their returning motion by stopping the current. The luminous spot then disappears, and when the beam is restored the spot re-appears, not in its normal position, but at the point it had reached when the rays were cut off. The speed of return is proportional to the throw, and the latter is proportional to the field. Under favorable conditions the author claims an accuracy to within 1 per cent for the measurements.—W. I. Milham, Physikal. Zeitschr., August 3, 1901.

HIGH POTENTIAL CURRENTS.

A COMMITTEE of the New England Insurance Exchange is considering the question of increased fire hazards incident to the establishment of high potential systems by electric street railways. Before any action is taken by the Exchange it is probable that the subject will be referred to the National Underwriters' Association, which draws the national electrical code. It is said here by C. M. Goddard, the secretary of the Exchange, that the fire insurance companies do not wish to put up the rates, and they will not act unless they have to. If there is a permanent increase of hazard, then the insurance companies, in order to be able to pay their losses, must increase the rate. Thus far the use of extra high potential systems has not been carried very far. There is one in Hartford, one in Providence, one in Brockton, and one in Maine.

The increased risk is due to the extension of the business of the trolley companies. They add more territory to what they have been operating and must have more power for the larger service. The extra high potential system is used, it is said, in order to save copper, and there is no imperative need for increasing the insurance hazard, if the trolley companies go to the necessary expense to avoid it. It is impossible, says Mr. Goddard, to guard against the hazard by means of insulation, but in the congested portions of cities, or on roads where there is much travel, the wires should be put under ground. In other localities the remedy proposed is to have the trolley cars obtain a right of way over private land, so that the wires shall be beyond danger of coming in contact with streams of water thrown upon fires, or in contact with the firemen themselves. It would be practically impossible for firemen to cut these wires of high potentiality. While there might not be accident, there

* Compiled by E. E. Fournier d'Albe in The Electrician.

would always be danger of it, and that would be enough to keep the firemen away from the wires entirely.—The Evening Post.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Trade in South Africa.—British trade is envious of the vast strides made during the last four years in the exportation of manufactures and products of the United States, particularly to British colonies and dependencies. It is suggested that "a coalition of those British manufacturers interested particularly in the mining, engineering, and allied trades should be formed without delay, to obtain sites in Johannesburg, where stocks may be kept for the prompt delivery of goods." This is to forestall possible similar action on the part of American manufacturers to secure the Transvaal mining trade. While the resumption of mining operations may portend much, I believe that there will be no immediate demand for mining machinery and appliances, for the reason that large orders have been placed (many in the United States), and at the coast ports much machinery, etc., can be found waiting for a clear track to the Transvaal. The shortage of cars may be accounted for, not only by the destruction by the Boer commandoes, but also from the fact that the construction of new ones is delayed by lack of men. Recently ten Baldwin and ten Schenectady engines have arrived, and have completed the 1,000 mile run required by the specification. Many objections to them have been made, particularly by the operators—objections too ridiculous to mention—but the engines are busy.

Railway Stock.—If the permission of the Portuguese government can be obtained a line of railway will be built from Delagoa Bay to Johannesburg. The line will be broad gage—4 feet 8 inches—and will cheapen the carriage of goods to Johannesburg over 50 per cent. Eighty miles from Delagoa Bay there has been found an abundance of coal, which will add to the value of the road. Delagoa Bay will in a short time be a port of great value to the Transvaal, and Johannesburg will probably reach a population of 500,000.

Mr. C. B. Elliott, general manager of the railways of Cape Colony, is now on his way to the Continent and the United States. In a recent interview he stated in substance, referring to purchases for the railways, that "a preference would be given to English manufacturers, with a certain margin." But he added that the Cape government was cosmopolitan, and if the Americans offered an article as good as that offered by England, at a price below the margin referred to, the order would be given to them.

Some time ago an order for 167 "steel self-dumping coal cars" was sent to an American manufacturer. These have arrived and are being erected at Cape Town and Port Elizabeth. They are several feet shorter than the English make, and yet carry more coal, and they are also more economical in delivery of the coal. The railway men, including the general manager, have expressed themselves as being pleased with them. The order, however, caused much complaint in England, on the ground that colonial orders for rolling stock were being diverted abroad.

UNITED STATES TRADE.

Great stress is laid upon the published statistics of Cape Colony and Natal, which show a decrease in 1900 (compared with 1899) of United States imports amounting to £334,507 ($1,627,878.32), while the increase of imports from the United Kingdom for the same period was £1,372,258 ($6,678,093.56). A decrease is also shown in the imports from almost every other country. The United States lost 12.6 per cent; Germany, 23.7 per cent; Belgium, 11.2 per cent; and Austria, 54.6 per cent. I contend, figures to the contrary, that 1900 has been the largest export year of the United States to South Africa. The statistics of 1900 cannot be depended upon, as there is an entire absence of returns from Delagoa Bay. One hundred and seventy-seven million cigarettes were shipped direct to Cape Colony and Natal by one house in the United States. The statistics will not show this, and yet to this number should be added, perhaps, millions more of United States manufacture that came in via England, Delagoa Bay, and Beira. The same may be said of canned meats, cereals, tobacco, etc.

I would note the trade in "granite wool" and other substances of like character for use in cold-storage and refrigerator structures. Over 1,000 tons of this material have already been ordered, and thousands of tons will yet be needed. Arc and incandescent lamps are having quite a sale; this municipality is using one kind from the United States, 5,000 having been bought. Candies, blotting paper, chairs, picture frames and moldings, sole leather, and many other articles are coming to the front. All these are new imports, and to this consulate some credit is due.

Cement.—I am pleased to note that since the publication of the report from this office on cement.* steps have been taken to establish an agency here, and if necessary the cement will be shipped in the manufacturers' chartered ships. It is time the United States had a share in the cement trade, for, while the demand has always been heavy, after the war it will be largely increased. The report on cement called forth the following from The British and South African Export Gazette:

"Of the total imports of cement into South Africa in 1899, Great Britain furnished about 73 per cent (£106,856 = $5,200,147), the balance being supplied by Germany and Belgium. If we compare this with 1889, when the United Kingdom shipped something like 95 per cent of the whole of South Africa's consumptive demands, it will be found that our exports thither have declined by as much as 22 per cent. Within the past five years, Belgium's contribution has advanced in the ratio of 40 per cent, and that of Germany by 125 per cent.

"While the actual exports of cement from the United Kingdom are nearly three times as much as from either of our two leading competitors (for America is at present altogether out of the running), their combined aggregate exports serve to powerfully enhance their significance. A competition which within five years has wrested one-third of our cement trade from us in only one of our possessions is indeed one to cause justifiable misgivings.

"The fact that the rapid rise of the continental cement trade is contemporaneous with the launching of certain great new foreign shipping lines sufficiently foreshadows the nature of the advantage to which it owes its progress.

"Attestation of this is furnished by so capable an observer as the American consul-general at Cape Town, who states that German cement, equal to the best English Portland, can be bought in South Africa at 1s., and Belgium cement at 1s. 6d., per barrel cheaper than English, shipped per steamer from Hamburg and Antwerp at 25s. per ton and 10 per cent primage, the forwardings from both these ports, as well as from other inland continental States to whom the preferential rates are open, being effected by the German shipping line, whose 'considerable cheapening of freight costs' is, as professed by them, achieved less by reduced sea freights—the conference agreement preventing this—than by reduced railway charges to the European port of shipment."

Shipments are arriving from Germany, the ruling price being 5s. 6d. ($1.34) a cask of 400 pounds. One firm in this city has sold during the year 80,000 casks and another 25,000 casks. I am told that there is now a "cement trust" in Germany, with a capital of $7,500,000. Belgian cement is quoted at 4s. 6d. ($1.095) a cask. These prices are f. o. b. Antwerp or Hamburg. The imports for 1900 were over 3,000,000 pounds in excess of those of 1899.

American Iron and Steel.—The recent prices of American merchant iron and soft Bessemer steel made an opening for a large trade in those commodities in South Africa. One of the largest merchants here received samples of 25 tons, which were taken to the railway shops for the making of bolts, etc., and to the coach builders for iron forgings and the like. Either the blacksmiths did not know how to work American iron, or the iron was not up to quality stated, for in working it was found to be brittle; it "would not weld or head well." The failure of this shipment has struck such a blow to the iron trade that, until samples arrive that will do the work required, no headway in this line can be made. I would suggest that when iron is shipped to this country instructions be forwarded as to the proper method of working, if this differs from the working of English iron and steel.

Bicycles.—During the year ended December 31, 1898, the increase in the imports of bicycles from the United States over the preceding year was 171 per cent, or $27,885.06—more than that of any other country. During the year 1899 the imports were less than in 1898, but more than in 1897. For the year ended December 31, 1900, a substantial increase is noticed. The formation of several bicycle corps for army service caused imports to advance. Many of the men furnished their own wheels, and the local agencies, both American and others, had all they could do, and stocks in store and on the water were inadequate.

Wagons.—It is gratifying to note the remarks of Lord Roberts regarding American wagons. He said: "Six buck wagons were imported for trial from the United States. These proved to be superior to any other pattern of either Cape or English manufacture. The wheels were of hickory, the bodies of black walnut, and the metal work of steel. The superiority of those vehicles was doubtless due to the fact that mule wagons are largely used in America for the carriage of goods, as well as for military transport. The manufacturers have therefore learned by practical experience what is the best type of wagon and what are the most suitable materials in building them. It may be added that the wagons in question cost considerably less than the Bristol pattern."

A shipment of these wagons is now on the water and large orders may be expected. Wagons for this market must use the "Peavey brake," which is operated from the rear by a screw.

Coal.—Many vessels arrived with steam coal in 1900, and there are now at this port three ships, and others at upcoast ports. Steam coal is now quoted at 50s. ($12.16) per ton. This seems high, but the freight from the United States is 25s. ($6.08) per ton. Owing to delays in discharging cargoes, freight rates cannot fall. A sample cargo of "coal briquettes" from Germany is on the water. These briquettes are composed of coal dust and tar, compressed under heavy pressure into bricks about three times the size of ordinary house bricks, and are worth 15s. ($3.65) less than Cardiff coal. It is stated that the grate bars using this fuel burn out rapidly under the intense heat generated. Coal imports for Cape Colony and Natal for 1900 were 131,000 tons ahead of those of 1899.

Lumber.—The trade for the year is highly gratifying and the United States has had the bulk. Twelve American sailing vessels are now awaiting discharge. The lumber is principally Oregon pine. For the year ended June 30, 1901, over fifty Swedish and Norwegian sailing ships have left South Africa for our southern ports to bring back pitch pine. It is to be regretted that American ships could not be found to do this work.

Leather.—Unmanufactured leather shows increased imports of about 1,000,000 pounds. I can only add that I regret that the exportation of sole leather from the United States was discontinued. It is not good business policy to stop exporting when a foreign market is once established, for the reason that the home market is again ample.

Food Articles.—Heinz, the man who makes fifty-seven articles for the table, has had one of his agents here, and the sales have been marvelous. Everybody is tasting the goods at stores where young ladies are cooking the soups, etc. These articles have come to stay.

General.—A comparison of United States trade in South Africa with that of other countries is satisfactory, and appears still more so when it is considered that our commerce with other countries, to which we have been selling for years, is less than with this country—a comparatively new one. Taking the imports from the United States at $20,086,128.36, it is shown that South Africa takes more of our products than does the Argentine Republic, Brazil, all the other South American States, the Chinese Empire, East Indies, Russia, Denmark, Spain, Sweden, Norway, Austria, Turkey, all the West Indies, not including Cuba, or all the Central American States; and this trade is only exceeded by that with the United Kingdom, Germany, Netherlands, France, Belgium, Italy, Mexico, Japan, or British Australia.

As to the future, it is said that plans are matured for expending $50,000,000 in new railways; that several thousand miles of telegraph lines are to be erected and renewed; that $5,000,000 is to be spent for public works, and $15,000,000 on harbors; that $500,000 is to be invested in electric lines in Natal; and twenty-five or more millions are to be expended in the Transvaal and a proportionate amount in the Orange River Colony. We must not fail to bid for this work.

No nation or municipality is so rich, especially after time of war, that it can afford to give to the highest bidder—even if he be of their own country—a contract to be paid for out of the pockets of the whole people. "The best goods at the cheapest price cannot be kept out of the world's markets." A country laid waste, with valuable mines long idle, public works much deteriorated, must recuperate, and it takes money and products of other nations to bring about such recuperation.

Our trade for 1899 and 1900 with the Uitlanders of the Boer States (our best customers in those States) has been lost, owing to their exodus. On their return to their old businesses their trade will again be open to us, and in time a great improvement will be witnessed, particularly in Johannesburg. The streets will be properly paved, and the sewerage system, so much needed, will be installed. A beginning has been made in opening up the mines, hotels, and stores. Goods are being forwarded by the military authorities, the dry goods merchants being permitted consignments of 10 tons, with the understanding that 50 per cent must consist of clothing and 30 per cent must be suitable for the poorer classes, while boot and shoe dealers are limited to 5 tons per shipment, 50 per cent to be suitable for the poorer classes. As soon as merchants have ample stocks, the military stores will be closed.

Advice to Manufacturers.—Allow me to suggest to the hundreds of our manufacturers who do not care to visit South Africa and must therefore send catalogues, not to print prices in the same, for the printed prices are not, merchants state, high enough to cover, in all cases, expenses connected with the receipt and selling of the goods. Naming net prices would be better, and then a distinction must be made between the regular dealer and the wholesaler, for the latter must be protected.

Canadian Trade.—A trade commissioner for the Dominion of Canada is on a visit to South Africa, with a view of ascertaining how an increase of trade between the two countries can be brought about. He claims that a large amount of Canadian goods is coming here—such as cheese, bacon, timber, and other products. He claims that if shipped direct, they could be placed upon the market more cheaply, thus creating a larger demand.—J. G. Stowe, Consul-General at Cape Town.

Rubber Culture in Nicaragua.—In forwarding the accompanying report on rubber culture on the old Mosquito Coast, prepared by Mr. Gordon Waldron, a Canadian gentleman (received by me through our consular agent at Bluefields), I have to remark that, judging from the experience of several people who have attempted rubber culture in this immediate vicinity, there would seem to be a reasonable doubt of universal success, notwithstanding the fact that the experiments were confined to localities where the wild rubber trees had been most abundant both in number of trees and yield of rubber. In two notable instances, after the plants had obtained from four to six years' growth, the planters became discouraged with the outlook, and, cutting down the young rubber trees, planted cocoa.

There is one rubber plantation remaining in this locality in which the trees are about eight years old, but the little bleeding attempted thus far has been unsatisfactory.

Taking the consensus of opinion of those indigenous to the soil, who have had an opportunity to observe the progress of a planted tree—planted occasionally by someone as a novelty—I would say that while there is no apparent reason why India rubber culture in certain localities of Central and South America should not be successful, it is well for those of limited resources who may have invested in rubber plantations to be prepared for disappointment, if they rely upon getting substantial returns from rubber trees of less than twelve or fifteen years' growth.—William B. Sorby, Consul at San Juan del Norte.

American Fire Brick in Ontario.—Commercial Agent Hamilton reports from Cornwall, August 29, 1901, that there is a great demand for American fire brick in the Province. It is being sold at $40 per 1,000. Scotch brick is also used, but it is inferior to the American, and only brings $18 per 1,000.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

* Advance Sheets No. 871 (October 27, 1900); Consular Reports No. 243 (December, 1900).

SELECTED FORMULÆ.

Hoof Cement.—

Gum ammoniac, purified	0.3 kilo.
Thick turpentine	0.1 kilo.

Melt in the water bath and gradually add with constant stirring, 0.6 kilo of gutta percha. If black hoof cement is desired, rub up 20 grammes of lampblack with a little turpentine before the melting. For use, soak the mass in hot water and press it into the clefts of the hoof, which have previously been carefully cleaned.

Red Russia Leather Varnish.—

Shellac	1.20 kilo.
Dammar resin, powdered	0.15 kilo.
Turpentine, Venice	0.60 kilo.

Dissolve with frequent shaking in 12 kilos of spirit (95 per cent), add 1.8 kilos of powdered red sanders wood, let stand for three days and filter. The object of this varnish is to restore the original color to worn Russia leather boots, previously cleaned with benzine.

Waterproof Shoe Grease.—

Olive oil	7.50 kilos.
Yellow beeswax	2.50 kilos.
Alkanin (anchusine)	0.01 kilo.
Mirbane oil	10 grammes.
Or	
Lard	7.0 kilos.
Fish oil	1.5 kilos.
Yellow beeswax.	

Melt and when lukewarm gradually stir in 0.3 kilo of thick turpentine and 0.7 kilo of purified wood tar. Fill into tin cans.

French Retouching Pomade.—

(For regenerating old oil paintings.)

White beeswax	2.5 kilos.
Elemi resin	2.0 kilos.
Lavender oil	2.0 kilos.

Carefully melt the wax and elemi, then add the lavender oil and stir until cool.

Directions.—The pomade is rubbed out on the painting with a soft rag, and after a few minutes, upon drying superficially, it is rubbed with a wad of flannel until a sufficient gloss is produced.

Belt Cement.—

Gutta percha	4.0 kilos.
Resin	1.0 kilo.
Asphalt	1.5 kilos.
Petroleum	6.0 kilos.

Heat in a glass balloon on the water bath for a few hours until a uniform solution is obtained. Let cool and add 1.5 kilo of carbon disulphide and allow the mixture to stand, shaking it frequently.

Directions for use.—The leather belts to be cemented should first be made rough at the junction surfaces, and after the cement has been applied, they should be subjected to a strong pressure between warm rollers, whereupon they will adhere together with much tenacity.

Modeling Wax.—

Yellow beeswax	5.5 kilos.
Lard	0.4 kilo.
Venice turpentine	0.7 kilo.
Finely levigated red bole	3.5 kilos.

Dissolve the wax, lard and turpentine in the water bath, stir in the bole and grind again finely, in the heat, in a paint mill.

Dark Inlay Varnish.—

Ozokerite	17 kilos.
Carnauba wax	3 kilos.
Turpentine oil	15 kilos.

Melt the ozokerite and Carnauba wax, then stir in the turpentine oil. This varnish is applied like a polish and imparts to the wood a dark natural color and a dull luster.

Liquid Tree Wax.—

Resin	6.0 kilos.
Tallow	0.5 kilo.
Alcohol	3.5 kilos.

First melt the resin, then add the tallow, and when all has been uniformly melted, remove from the fire. When lukewarm stir in the alcohol and fill into the wide-necked bottles. This tree wax is applied with the brush.

Kid Reviver.—

Clear chloride of lime solution	3.5 kilos.
Spirit of salammoniac	0.5 kilo.
Scraped Marseilles soap	4.5 kilos.
Water	6.0 kilos.

Mix chloride of lime solution and spirit of salammoniac and stir in the soap dissolved in water. Revive the gloves with the pulpy mass obtained, by means of a flannel rag.

Patent Leather Preserver.—

Carnauba wax	1.0 kilo.
Turpentine oil	9.5 kilos.
Aniline black, soluble in fat	0.06 kilo.

Melt the wax, stir in the turpentine oil and the dye and scent with a little mirbane oil or lavender oil.

Directions for use.—The paste is rubbed out on the patent leather by means of a soft rag, and when dry should be polished with a soft brush.

Saddle Paste.—

Ceresine, natural yellow	1.5 kilo.
Yellow beeswax	1.5 kilo.
Japan wax	1.5 kilo.

Melt on the water bath, and when half cooled stir in 8 kilos of turpentine oil.—Seifensieder Zeitung, Augsburg.

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